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Discovering Our World

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BASIC STUDIES IN SCIENCE

Discovering Our World

SCIENCE FOR THE MIDDLE GRADES

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W. J. GAGE AND COMPANY LIMITED

Toronto

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ACKNOWLEDGMENTS

ACKNOWLEDGMENT IS MADE to the following for permission to publish the photographs on indicated pages: Acme Newspictures, Inc., 30 (centre), 36, 53, 56, 76 (right), 162 (left), 242; J. C. Allen from Ewing Galloway, 91 (left); Aluminum Company of America, 119; American Airlines, 47 (top); Gustav Anderson from Ewing Galloway, 132; L. D. Bailey and *American Forests*, 20; Dr. A. Allen Bates and the Westinghouse Electric Corp., 138; Carl Berger, 9 (left); *Better Homes and Gardens*, 97, 233; Black Star, 49, 52, 78 (right); Brown Brothers, 15; L. W. Brownell, 22, 24 (left), 31 (bottom), 40, 218; Caterpillar Tractor Co., 169; Century-Allen, 13, 146 (right), 190; Century Photos, Inc., 18, 21, 152, 168 (left), 170, 182, 183, 186, 187; Chicago Academy of Sciences, 30 (top); Chicago and North Western Railway, 63; Chicago Natural History Museum, 10, 12, 37; Cleveland Board of Education, 220, 229 (left); Cushing from Sawders, 101 (right); De Laval Steam Turbine Co., 61; G. A. Douglas from Gendreau, 98 (left), 100 (left), 106 (left); Ewing Galloway, 33 (left), 46, 54 (top), 83 (right), 90, 121, 140, 143, 144, 161, 162 (right), 176, 214, 237; Philip D. Gendreau, 50, 51, 106 (right), 226 (left); Hercules Powder Co., 142; Ferdinand S. Hirsh, 14, 96, 102; The Hoover Co., 57; Paul G. Howes, 16, 17, 32 (left); International Harvester, 33 (right), 58 (left), 204; Robert H. Johnson, 172; Kaufmann & Fabry Co., 58 (right), 64 (top), 92; Keystone View Co., 101 (left); Keystone-Underwood, 55 (left); Leon Koenigsberg, 27 (centre-right); Erling Larsen from Frederic Lewis, 98 (right); *Life,* 193; Courtesy *Life,* (c) *Time,* Inc., 178; *Look* from The National Safety Council, 166; *Market Growers' Journal,* 227; Meisel from Monkmeyer, 141; Merck & Co. from the American Institute of Baking, 191; A. F. Mueller, 94; Museum of Science and Industry, 146 (left); J. Horace McFarland Co., 24 (right), 25 (right); National Dairy Council, 195, 196; National Safety Council, 165, 168 (right), 171; Dr. E. Lawrence Palmer, 174; *Parents' Magazine* by F.P.G., 74; *Popular Science Monthly,* 95 (left); William J. Robbins and The New York Botanical Garden, 212; Rock Island Railway, 59; Albert I. Rose from Frederic Lewis, 87 (right); William A. Scharon, 44; Ben Schnall from Frederic Lewis, 91 (right); *Screen Traveler* from Frederic Lewis, 78 (left); A. F. Sozio from Gendreau, 100 (right); Hugh Spencer, 25 (left), 27 (left, left-centre, right), 28 (right, left), 30 (bottom), 208, 210 (right), 217; Tennessee Dept. of Conservation courtesy The American Forestry Assn., 38, 41 (right); Trowbridge from R. I. Nesmith, 70; Underwood and Underwood, 9 (right); U. S. Beet Sugar Assn., 206; U. S. Bureau of Reclamation, 47 (bottom); U. S. Dept. of Agriculture, 26, 31 (top, centre), 41 (left); U.S.D.A., Bureau of Entomology, 32 (centre, right); U.S. D.A., Bureau of Home Economics, 192; U.S. D.A., Bureau of Plant Industry, Soil, and Agricultural Engineering, 28 (centre), 29, 207, 225, 226 (right), 230, 232 (left), 234; U.S.D.A., Forest Service, 148; U.S.D.A., Soil Conservation Service, 34, 35, 181, 238; U. S. Dept. of the Interior, Fish and Wildlife Service, 19, 42; U. S. Gypsum Co., 163; H. A. Vandenbree, from *The Instructor,* Dec., 1942, by permission of Miss Isobel Willcox and the F. A. Owen Publishing Co., 6; Wincharger Corp., 68; Wisconsin Conservation Dept., 39.

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To the Boys and Girls Who Study This Book

For hundreds of years, explorers have been discovering new places in the world. Columbus discovered a new land, and other explorers discovered new regions in many parts of the earth. But nearly all of the lands in our world have now been discovered and explored.

Travelling to faraway places is not the only way of discovering our world. We also discover our world when we learn what kind of world it is. All around you, there are thousands of things that you have never seen or heard about. They are just as interesting and just as exciting as anything that the great explorers ever found.

In this picture the boys and girls are discovering interesting things about the world they live in. You are very much like these boys and girls. You have eyes and ears, and you can think and plan. You can see and hear many of the things that go on around you, and you can find out how they happen.

Here are some of the things that happen near you every day. Can you explain how they happen?

Water flows downhill.

Animals help plants.

Plants help animals.

Fire makes things burn.

Bees help flowers make seeds.

Green plants make food from materials in the soil and air.

Steam locomotives pull trains.

People plant tiny seeds that grow into flowers or vegetables.

Probably you do not know how these things happen. But do you know how to find out?

One way to find out how such things happen is to *look carefully* at the things around you. To do this, you need to think about what you are seeing. You need to take plenty of time so that you will discover as much as you can.

Another way of finding out about the things around you is to *read* books. There are certain things to remember when you read books to get information. Some books are written to be read for fun. They do not always give you correct information. Be sure that the books you read for information were written by authors who write books to give information. You may have to read several books before you decide whether the information is correct.

The books you read in science should not be too old. The science information in old books may have been

thought correct when the books were written. But new discoveries are made every year. And so new books are likely to be more nearly correct.

One of the most interesting ways of discovering new things is to do experiments. When you experiment, you try out different things to see how they work. You will want to do many experiments so that you can learn about the things around you.

When scientists do experiments, they use many of the things you see in the picture on page 7. Perhaps you will have some of these things to use at school. But if you have not, you can do many experiments just as well with bottles, glasses, and other things that you bring from home.

There are certain things you should be careful about when you experiment. Read this list of things to do and try to think of them while you are doing your experiments.

1. Be sure to follow the directions that are given in your book.
2. Watch carefully to see what happens.
3. Think carefully to understand why it happens.

4. Try your experiment more than once so that you can be sure that you do it correctly.

5. Always work carefully.

Many of the discoveries in our world have been made by scientists. Scientists are men and women who study the things on the earth and inside the earth. They are really discovering our world because they are always finding out new things about it.

Scientists discover new things by experimenting and by looking carefully at things about them. They make many discoveries in their science laboratories. But they also make discoveries wherever they happen to be.

Not all of your science discoveries will be made in your schoolroom. Many of them will be made at home and everywhere around you outdoors.

If you want to find out what discoveries this science book will show you, look at the Contents on page 3. It will tell you some of the things that you are going to learn.

If there are some other questions that you would like to ask, make a list of them. Then see how many of them you can answer as you study Discovering Our World.

As you use this book, you will find some new words that scientists use. You will want to know what they mean so that you can use them, too. In the back of this book is a list of Science Words. The list tells you how to pronounce them. It also tells you what the words mean. Turn to page 246 and look at the list of Science Words so that you can see how it will help you.

★ In Unit One You Will Learn ★

★ *How animals help each other* ★ *How plants help animals* ★
★ *How animals help plants* ★ *How plants help each other* ★
★ *How plants harm other living things* ★ *How animals harm other living things* ★
★ *How plants help us* ★ *How animals help us* ★
★ *How we conserve the living things that help us* ★

⋆ UNIT 1 ⋆

How Do Living Things Help and Harm Each Other?

Do you know that fish helped make buttons for your clothes? Many buttons are made from clam shells. Not many years ago, the men who make these little white buttons became worried, because the clams were disappearing. So the men asked scientists to find out why. This is what the scientists discovered.

When young clams are first hatched from eggs, they are not much bigger than a pinhead. They float around in the water until they fasten themselves to the gills of fish. There they stay until they are big enough to live without the help of the fish. The young clams that do not fasten themselves to the gills of fish soon die.

Can you guess why the clams were disappearing? It was because fishermen had caught most of the fish that the clams needed. So, of course, the clams could not stay alive. Without the fish there could be no clams, and without the clams there could be no shells for buttons.

This story tells you just one of the many strange ways in which living things need and use each other. Here is another story that shows you how living things help and harm each other.

Would you believe that mountain lions and wolves could save a forest? High up in the mountains in the western part of North America, there is a beautiful forest. A few years ago, many of the trees and other plants in this forest were dying, because deer were killing them. This may seem strange, because deer have lived in forests for hundreds of years without destroying the forests.

Yet this is what was happening. In this forest, wolves and mountain lions had been killing many of the deer and eating them. The men in charge of the forest decided to kill the mountain lions and wolves so that the deer would be safe.

After the men did this, almost every deer that was born grew to full size.

If many deer ate the twigs and bark of these trees, what would happen to the trees?

The herds of deer became larger and larger. Soon the herds were so large that there was not enough food for them. They became so hungry that they gnawed the bark off the trees. Of course, this killed many trees. Then the men had to kill some of the deer to save the trees. Do you see now how the wolves and the mountain lions had helped save the forest?

This story you have just read about the forest, the deer, the mountain lions, and the wolves shows another one of the strange ways in which plants and animals need each other and use each other. Living things need other living things almost as much as they need air and water.

You, too, are a living thing. Every day of your life, your plant and animal neighbors help you in some ways and harm you in other ways. This unit will tell you many ways in which living things need and use each other. You can discover many other ways yourself if you watch your living neighbors closely when you are outdoors.

Before you read these pages about plants and animals, you must be sure that you do not get a wrong idea. Do not get the idea that plants and animals know that they are helping or harming each other. Plants and animals need food, shelter, air, water, and light. As they try to get these things, they sometimes help and sometimes harm other living things. This helping and harming just happen to take place. The living things do not plan to help or harm each other.

Suppose you take a walk across the fields and through the woods or to some park in your town. Watch every animal you see and try to find out what the animal is doing. Study the plants you find. As you watch these living things, try to find answers to these questions. How do living things help each other? How do living things harm each other?

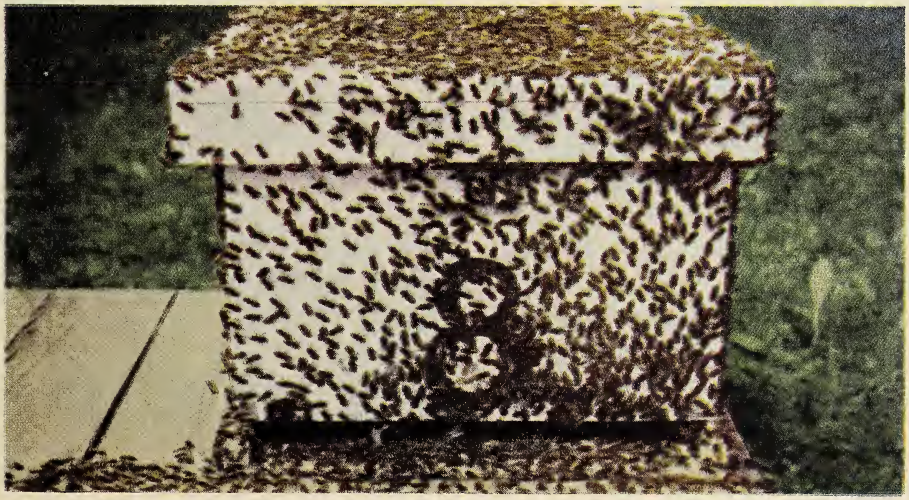
How do animals help each other?

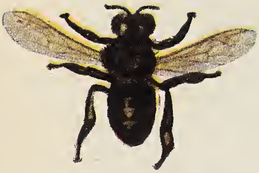
One day, a science class went to parks and vacant lots in their town to watch plants and animals. The boys and girls also kept watching after school and on weekends when they were outdoors. They watched to see what they could find out about how living things help each other. Then they talked about what they had seen. First, they talked about animals.

"I know one way animals help each other," Henry said. "My father keeps honeybees, and I know that bees live together in hives."

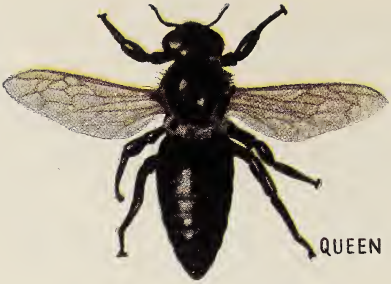
The teacher then told the class that honeybees are called *social* animals because they live and work together. They have to live together in a *colony* to stay alive. Sometimes there are as many as 60,000 bees living in a colony.

This colony of bees has left its old home and is moving into a new one.

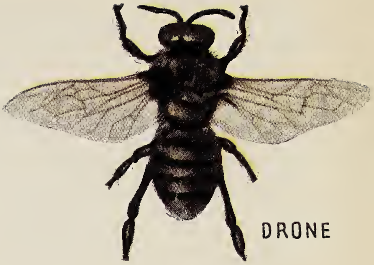




WORKER



QUEEN



DRONE

Almost all of the bees in the hive are called *worker* bees. They do all the work of the hive. Other bees are called *drones.* There are not many drones in a hive. They do no work, but the bee family could not get along without the drones. A drone is the father of the colony. All of the bees are either workers or drones except one bee. This bee is the largest in the colony. She is the mother and is called the *queen* bee. The pictures at the top of this page show you a worker bee, a queen bee, and a drone.

A beehive is almost like a city, with every bee doing a certain kind of work. Some bees fly over the fields and meadows, gathering materials for food. They find these materials in the flowers of plants. One of the materials is a sweet juice called *nectar.* The bees use the nectar to make honey. This honey is food for the bees. Bees also gather *pollen* from the flowers. Perhaps you have seen pollen in flowers. It looks like yellow dust. Bees use the pollen to make a kind of food called *beebread.*

Some of the worker bees are wax makers. These bees eat all the food they can and then attach themselves to each other and hang in long strings from the top of the hive. Each bee clings to the bee above it. In a short time, wax begins to ooze from the undersides of their bodies. Other worker bees take this wax and use it to make honeycombs. In these wax combs, the bees store their honey. They also put beebread in these combs. The queen bee lays her eggs in these combs, too.

Some of the bees are housekeepers. They pick up the pieces of wax that fall to the bottom of the hive and carry them outside. When bees die in the hive, these housekeeper bees carry the dead ones out.

Of course, there is always danger that some enemy may enter the hive. It is the duty of the guard bees to make sure that no strangers enter. If a wasp or some other strange insect or a bee from another colony tries to come into the hive, the guard bees fight it and sting it to death.

These hundreds of worker bees must be supplied with fresh air while they are working in the hive. So some of the bees fan their wings swiftly back and forth to move the air and to bring in fresh air.

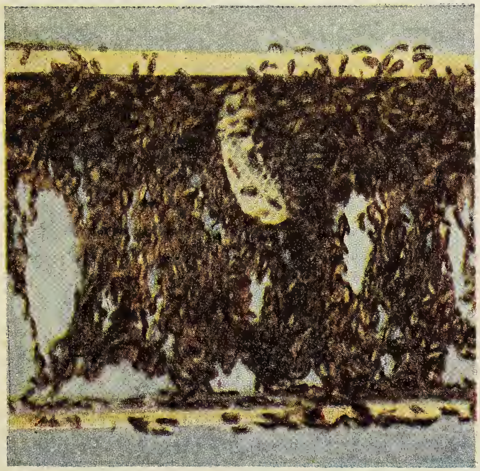
But all of this work would be useless without the queen. The queen bee lays all the eggs. Without her, there would be no new bees to take the places of those that die. The hive would soon be empty, because workers live only about six weeks.

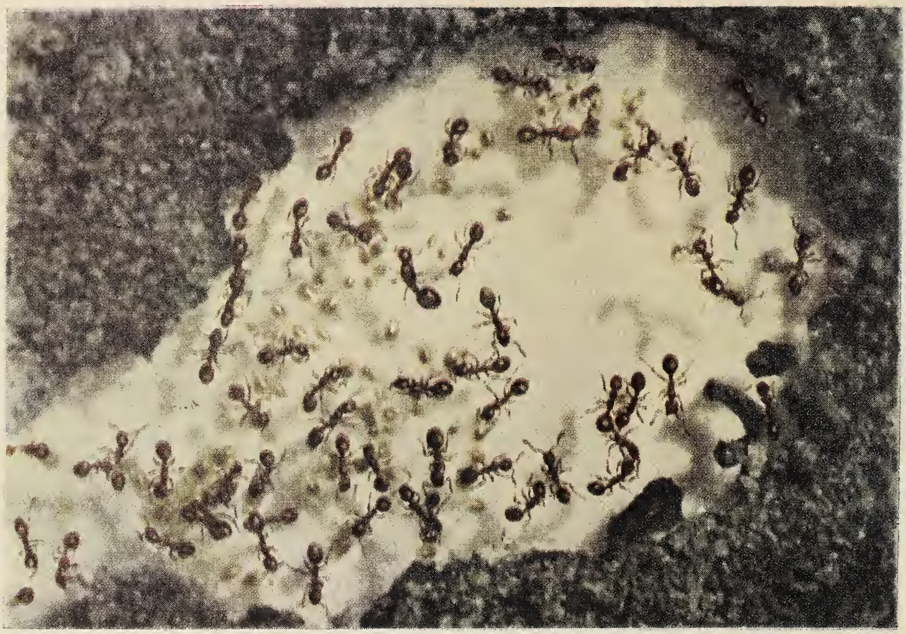
Does the way the bees divide up their work remind you of a community? In a city or a town there are street cleaners, policemen, carpenters, storekeepers, and many other kinds of workers. They help each other by doing different kinds of work. No one person does everything.

But there is one very important difference between a bee community and a community of people. Men and women *plan* the work in a community. They know why they help each other, and they know that they are helping each other. Bees cannot think. So, of course, they cannot plan. They live together and help each other without knowing why they do so. They do not even know that they are helping each other.

Ants also are social insects. It will be easy for you to have a colony of live ants in your classroom. You can dig up an ants' nest and put it in a glass jar with a fine screen over the top. Then if you tie paper around the jar so that the light will be shut out, perhaps the ants will make tunnels in the soil near the glass.

In the picture at the left, some of the bees are making the honeycomb. On the right, the bees are filling the comb with honey.





Here is part of an ants' nursery. The small, light-colored objects are young ants.

Most of the brown or black ants live in nests built in sand or loose soil. Here they dig long tunnels and make many rooms. Some of these rooms are nurseries where the young ants are taken care of until they can take care of themselves.

There are also storerooms for food. And would you believe it, some rooms are used for sleeping! Yes, ants sleep. When an ant returns to the nest, carrying a supply of food, other ants rush out to meet it. They brush the dust off the ant. Then the ant goes to one of these sleeping rooms where it soon is fast asleep.

There are three kinds of ants in an ant colony, just as there are three kinds of bees in a bee colony. But in an ant colony there are usually several queens. In a very large colony of ants, there may be fifty queens. The queen ants lay the eggs, too. In every nest, there are hundreds of worker ants. Some go to get food. Some look after the queens and feed them. Other workers take care of the eggs. Others guard the colony.

Scientists who have studied ants have found a very strange way in which animals help each other. They have found out that ants keep "cows."

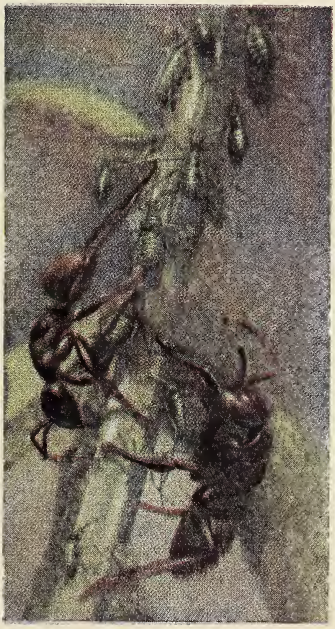
The ant cows are really little plant lice, called *aphids*. The picture on this page shows two ants with their cows. These aphids suck the juice, or sap, from plants. The aphids use some of this juice for food. But ants "milk" the ant cows to get some of the juice for themselves. They do this by stroking the ant cow with their feelers. When the ant cows are stroked, they give off a drop of the juice. Then the ants drink the "milk."

But this is only part of the story. The ants take good care of their herd of ant cows! They keep other insects from eating the aphids, and they take care of the aphids' eggs. Through the cold winter, the ants keep the eggs and the cows down in the ground where they will not freeze. When the warm spring days come and the leaves are growing on the plants, the ants bring the newly hatched plant lice out into the sun and put them on the leaves. There the plant lice have plenty of food. The ants have really taken their cows out to pasture!

You can find many other examples of how animals live together. If you watch a mother and father robin feed the young birds, you will discover that the parent robins make hundreds of trips every day to bring food to the hungry young robins. Even after the young birds have begun to fly, the mother and father bring them worms and insects. The bird family lives together only as long as the young birds need to be taken care of. Then the family life is over.

Many other animals live together while the young need the mother's care. When young rabbits are born, they are as helpless as little kittens. For many days after young rabbits are born, they snuggle close to their mother and drink milk from her. The mother keeps them warm and safe.

Some kinds of animals join together so that they can capture food more easily. A group of wolves is called a *pack*. When a pack of wolves finds a deer or an elk in the woods, the wolves attack the animal and eat it. One wolf would have a hard time killing the larger animal, but many



"Gophers" sometimes live together in villages. One or two sit up on top of their mounds to keep watch for enemies.

wolves together can kill it easily. Birds often join together to fight an enemy. Did you ever see a flock of little birds chasing a big crow that had been trying to rob their nests of eggs?

Some kinds of animals warn each other of danger. Beavers do this by striking their flat tails on the water. This makes a loud noise. It is the signal for other beavers to dive under water and swim to their homes. Crows give warning cries, and the flock flies to shelter and safety. Many other kinds of animals help each other by giving warning signals.

Animals need and use other animals in many, many ways. It would take you a long, long time to find out all there is to know about these ways. If you have been watching your animal neighbors and reading about them, you have probably discovered many things that are not told in this book.

---

1. *Why are some animals called* social *animals? Give some examples of social animals.*
2. *List some ways in which animals help each other by living or hunting in groups. Give an example of each way. If you can, name other animals than the ones given in this book.*
3. *What is one big difference between an animal community and a human community?*

How do plants help animals?

When the boys and girls of the science class had learned how animals help each other in many ways, they decided to find out how plants help animals. One Saturday, Bill and John took a hike through the woods and across the fields. They had not gone far before they saw a squirrel scampering along the ground. Soon they saw that he was helping himself to nuts that lay on the ground under some hickory trees. Quietly the boys watched. They saw the squirrel carry the nuts away to a hole high up in a tree.

"The squirrel eats the nuts and uses the tree for a home, too," said Bill. "And, of course, a tree is a plant."

As Bill and John walked along, they saw other animals using plants for food. Cows, horses, and sheep were eating grass in the fields near the woods. Birds were eating fruits in the trees, and other birds were picking up the seeds of plants.

"Some animals certainly could not get along without plants," said John. "They use plants for their food."

All animals need plants. Horses, cows, sheep, deer, and elephants never eat meat. Cats, dogs, tigers, lions, foxes, and many other animals eat meat. But even these animals could not live if there were no plants, because the animals they eat use plants for food. All animals must live in a place where there are plants.

A duck has made a nest in the tall reeds. Her eggs will be well protected there.

As the boys were walking along the edge of a grassy field, they were startled by a sudden noise in the grass. There, almost under Bill's feet, a tiny mouse jumped up and bounded away across the field. The boys searched in the grass, and in a minute they were bending over a nest of tiny mice. The tall, thick grass and the weeds made a very good place for the mother mouse to raise her family. Here she was protected from her enemies and from the hot sun. The inside of the nest was lined with soft grass and leaves.

While the boys were looking at the nest of mice, they heard a tapping sound on a tree near by. A woodpecker was using its strong, pointed beak to make a deep hole in the tree. In this hole, the woodpecker would lay her eggs. When the eggs were hatched, the hole would make a good home for the young woodpeckers. The flicker in the picture is using a hole in a tree for her home.

Many other birds find good nesting places among the branches of the trees. An oriole hangs its basketlike nest from one of the highest branches. It uses grass and twigs to make the nest. Most birds could not make their nests without using grass, twigs, leaves, or the bark of plants.

There were many other animals in the woods, but the boys did not discover them. These animals were small, and the boys never thought to look for them in their hiding places. If they had looked under the leaves of plants, they would have found many kinds of insects. Many kinds of small animals live under the leaves of plants that grow close to the ground. Crickets, grasshoppers, ants, small moths, cutworms, spiders, and snails live in the shelter of these leaves.

---

1. *What are some of the ways in which plants help animals?*
2. *Name five different animals that you have seen using plants. Tell how the plants helped the animals.*
3. *Explain why grass is very important in your life.*

In the picture on the left, bees are crawling over a flower looking for nectar and pollen. The bee at the right has many grains of pollen sticking to its body.

How do animals help plants?

It was rather easy for the boys and girls to see how plants help animals. But, at first, they could not see how animals helped plants very much. Animals always seemed to be destroying plants by eating them. But the boys and girls started out to see what they could discover. They read, asked questions, and looked carefully at plants and animals.

One of the most interesting things the boys and girls learned was how bees help flowers. You have probably seen bees crawling around over them. You know that the bees are gathering nectar and pollen. Pollen is very important to flowers. Plants cannot have seeds unless pollen gets down into the part of the flower where the seeds are made. Seeds will grow into better and stronger plants if pollen from one plant gets into the flowers of another plant.

Bees carry pollen. When a bee climbs into a flower, some of the dust-like pollen sticks to its hairy legs. When the bee crawls around on another flower, some of this pollen is brushed off. So every flower that the bee visits gets pollen from some other flower. Many kinds of flowers cannot make seeds at all unless bees or other insects carry the pollen. In this way, bees and flowers are like partners. Bees get nectar and pollen that they need for food. The flowers get the pollen that they need to make the seeds that will grow into new plants. Many butterflies, moths, and other kinds of insects also help spread pollen from flower to flower.

Animals help plants in another interesting way. Insects are the most dangerous enemies of plants. Scientists say that if all the insects that are born were allowed to live, in ten years they would eat up all the plants in the world. But birds are the greatest protectors of plants. Many kinds of birds eat insects for food. In this way, millions of insects are destroyed every day. So these birds are helping the plants stay alive.

You will hardly believe the number of insects that birds eat. Scientists have figured that the birds in Nova Scotia eat about 21,000 bushels of insects a day during the summer months of the year! Each bushel has about 120,000 insects in it. Scientists say that in southern Ontario birds eat 3 million bushels of harmful insects every year.

Earthworms are animals that also help plants. Sometimes they are called "living plows," for they dig their way through the ground by eating soil. The soil goes in one end of the earthworm and out the other. In this way, earthworms help keep the soil loose, so that air and water can get down to the roots of plants. Perhaps you have seen little piles of soil near holes that earthworms have made in the ground. These little piles

Can you see the little piles of soil near this earthworm's hole?

are made of the soil that has gone through an earthworm.

A scientist once figured that an acre of good garden soil had 50,000 earthworms in it. He also figured that 36,000 pounds, or 18 tons, of soil passed through the bodies of these earthworms every year. Perhaps you thought that earthworms were good only for fish bait, but now you can see that they help the roots of plants get the air and water the plants need to stay alive.

The day that Bill and John hiked through the fields and woods, they found that they had helped plants in a very strange way. They had not planned to help, and they did not notice how they were helping until they sat down under a tree to rest.

"Look at your pants, Bill. They're covered with burs!" said John.

Bill laughed, "Look at them on your sweater, too."

The boys found many kinds of plant seeds sticking to them. As they picked the seeds off, they dropped them to the ground. Do you know what probably happened to the seeds?

Animals that have fur or hair are the best carriers of these seeds that stick tight. They carry them far and wide until the seeds fall off or are rubbed off. In this way, the seeds from one plant may grow into new plants miles away. Did you ever pick burs out of the hair in a dog's tail? Inside these burs, there are many seeds. After you dropped them on the ground, they probably grew into plants far from the place where the dog picked them up. Their free ride on the dog's tail helped the plants spread.

Seeds sometimes get faster rides than dogs, sheep, horses, and other four-legged animals can give them. They are carried far and fast by birds flying from place to place.

1. *Bees and flowers are partners. Tell how each one helps the other.*
2. *What are the most dangerous enemies of plants? What animals help protect the plants against these enemies?*
3. *How do earthworms help plants?*
4. *Give one reason why you find the same kinds of plants growing in so many different places.*
5. *Tell some of the ways in which animals help plants. Give an example of each way. If you can, name other animals than the ones given in this book.*

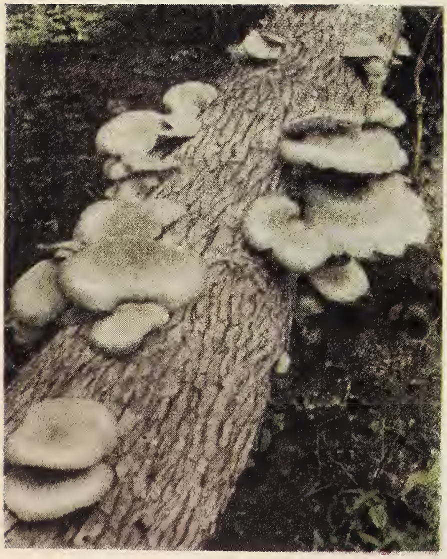
How do plants help each other?

WHILE THE CLASS was watching plants and animals to see how they help each other, the children were bringing to school many interesting things that they found outdoors. One day, Nancy brought to class a strange-looking thing that she had found growing from the side of a log. The picture at the left on this page shows you what Nancy found.

"It surely isn't an animal," said Nancy. "And it doesn't look like a plant."

But it was a plant even though it was not green. It was a kind of plant called a *fungus*. We call them *fungi* when we are talking about more than one fungus. There are many different kinds of fungi. You will find them growing on other plants. Sometimes they grow on live plants, sometimes on dead plants. They even grow on animals. Sometimes they grow out of soil that has decayed plants in it. Fungi cannot make their own food as green plants do. So they get food by using the food that the green plants have already made.

The fungus growing on the tree shows you that plants sometimes help other plants by supplying them with food. Mushrooms and puffballs are also fungi. They cannot make their own food, either. They grow in the ground, but they get their food from plants that have died and decayed.



The mistletoe that we use for decoration at Christmas time must have the help of other plants, or it cannot grow. It is not a fungus, for it can make its own food. But mistletoe does not get water from the soil. And, of course, it must have water to stay alive. Mistletoe gets water by fastening itself to the branches or trunk of a tree. As the water from the roots travels up through the tree, the mistletoe takes the water it needs to stay alive.

Have you ever seen a jack-in-the-pulpit, like the one in the picture on this page? You will have to hunt in the damp, shady woods to find one. This plant will not grow in the bright sunlight. It must be protected by other plants. Ferns, too, need the protecting shade of larger plants around them. Many kinds of plants that cannot grow in the hot sun are helped by the shade of other plants.

In a woods near a field that was once a forest, there are many kinds of plants that do not grow in the field. These plants used to grow where the field is, too. But after the trees were cut down, these plants could not stay alive, because the shade was gone. The plants in the field are ones that grow in the sun and do not need shade.

But some plants need the help of other plants to get sunlight. Look at the picture on this page. The vine has climbed up until it almost covers the tree. It is using the tree to lift itself up into the sunlight and the air.

There is one way in which every plant helps some other plant. When the plant dies, it falls to the ground. Then it slowly decays and becomes part of the soil. When leaves fall from the trees, they mix with the soil and decay. The food materials in the plants and leaves go back into the soil, where they can be used again by new plants. Have you seen the black, spongy soil in a forest? Other plants grow well in this rich soil.

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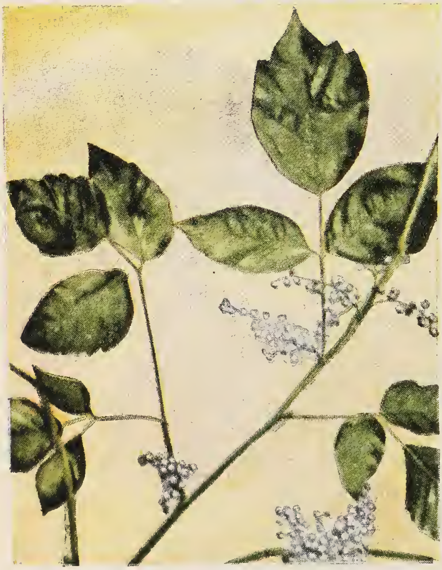
1. *What is a* fungus? *Name some* fungi.
2. *How is a fungus different from a plant such as grass?*
3. *Why must mistletoe grow on other plants?*
4. *How do some plants help other plants get sunlight?*
5. *Why are plants in forests often different from plants that grow in open fields?*
6. *How do all plants help other plants get food?*
7. *List as many ways as you can in which plants help other plants.*

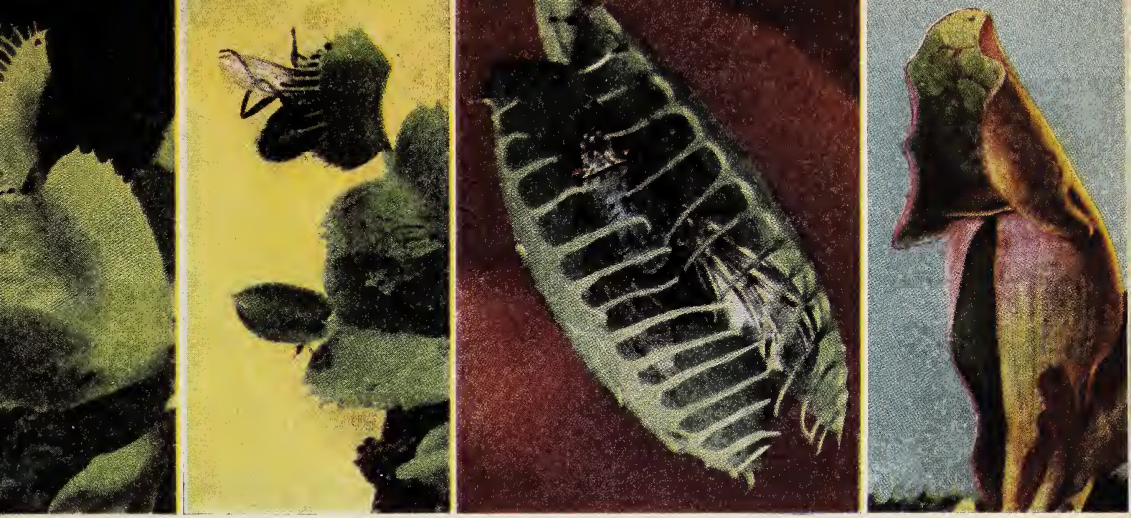
How do plants harm other living things?

ONE MORNING Bill came to school with his arms and hands almost covered with bandages. Everyone wanted to know what the trouble was. Bill explained that his arms and hands were covered with poison ivy rash. He had been out on a hike Saturday and sat down to rest. He did not notice the poison ivy on the ground.

Some of the boys and girls did not even know what poison ivy looked like. So the teacher showed them a picture like the one on this page. Look closely at the picture so that you will remember what poison ivy looks like. Sometimes the leaves have smooth edges, and one kind has leaves that look like oak leaves. But



Notice that the leaves are in three's!



You may be surprised to learn that some kinds of plants eat insects! The Venus's-flytrap is a plant like this. Its leaves have short bristles on them. When an insect lights on the leaf and touches these bristles, the two halves of the leaf come together. The insect is trapped. The pitcher plant has leaves that look like a pitcher. They have bristles inside of them. An insect that crawls down inside the leaf cannot get out again.

they are always in three's. The stems and white berries are just as poisonous as the leaves.

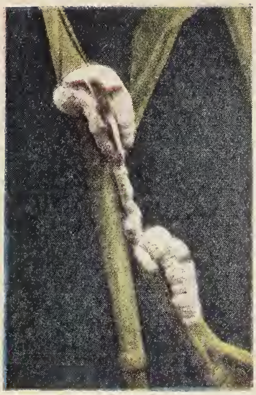
If you touch poison ivy, the first thing to do is to wash yourself with laundry soap and hot water. But it is best to learn to know the plant so that you will not touch it.

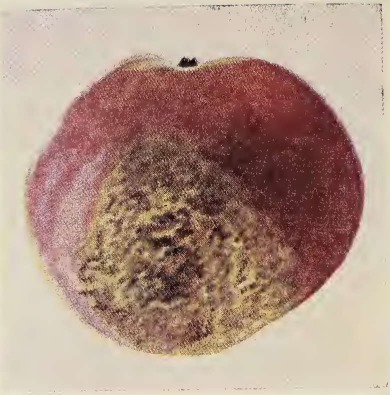
You have been discovering how plants and animals help each other. Bill's experience shows you that plants may also harm other living things. Perhaps you have been pricked and scratched by thorns. These thorns scratch and tear any animal that brushes against them.

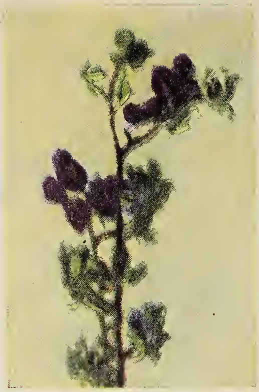
If you live on a farm, you may know that cows sometimes get sick from eating a plant called white snakeroot. This plant poisons the milk of a cow. There are several kinds of plants that make horses, sheep, and cows sick and may even kill them. Many kinds of plants will also make people sick and sometimes kill them. If you are hiking out in the country, never eat berries or any other parts of plants unless you know that the plants are harmless.

The mistletoe that you read about on page 25 shows another way in which plants harm living things. Mistletoe robs trees of water. If mistletoe grows too thickly on a tree, the tree will die. The fungi that grow on living trees harm the trees by taking food from them.

There are many kinds of fungi. Some are tiny. Some are big. Whenever they grow on living things, they







are harmful because they are using the living things for food.

Some kinds of mushrooms are good to eat. You can buy them in almost any grocery store. But other kinds of mushrooms are deadly poisonous. Only people who know the difference between the kinds that are poisonous and the kinds that are not poisonous should ever pick mushrooms to eat. Many people have died from eating the poisonous kinds.

Look at the pictures on this page. Do you see how the corn, the apple, and the plums have been spoiled? Tiny fungi have spoiled them. If you live on a farm, you probably know about such things as wheat rust, apple rust, potato blight, and corn smut. These are all diseases of plants that are caused by tiny fungi.

If you want to see what one kind of fungus looks like, keep some bread moist for a few days. You will see mold growing on it. Mold is a fungus. Perhaps you have seen mold on old damp leather or on fruit that has spoiled.

There are other very tiny plants called *bacteria.* Some kinds of bacteria often harm other living things. They cause many of the diseases that we may have. They also cause some of the diseases that farm animals may have. Some bacteria even attack other plants and give them diseases.

You learned that every green plant needs to get water and food materials from the soil to keep growing. You also learned that plants must have sunshine so that they can grow. If plants are too close together, some of them take water and sunlight from others. The stronger plants live. But the weaker ones grow poorly, or they die. Weeds in your garden are enemies of your flowers and vegetables because the weeds take sunlight, food materials, and water from them. If there are too many trees in a yard, there may not be enough water for all of them. And the lawn may be shaded so much that grass does not grow well.

When plants grow farther apart, they are not shaded by each other's leaves. So there is plenty of sunlight for all of them. Their roots can find plenty of water, too. Where too many plants are growing close together, every plant is an enemy of every other plant. It is almost as if they were fighting each other for the things they need to keep them alive.

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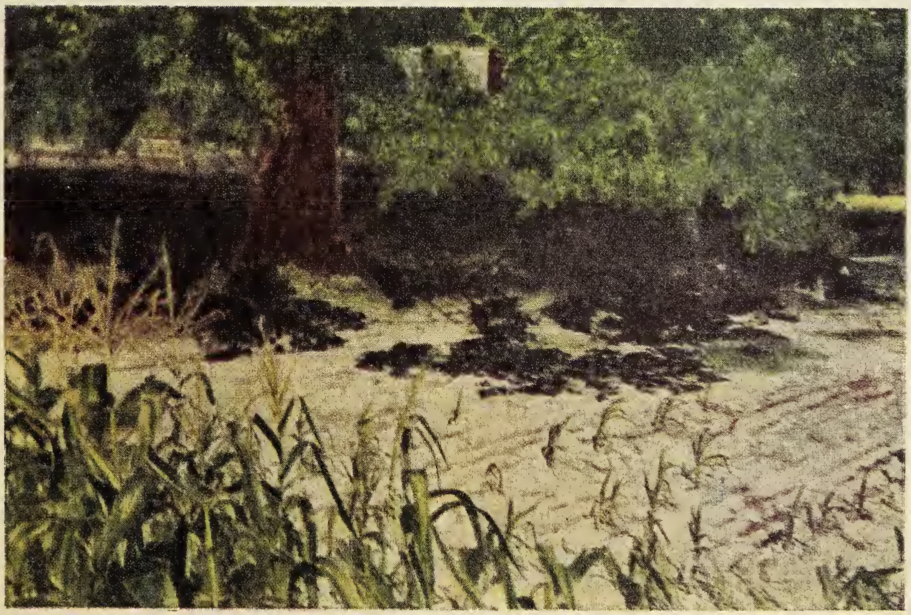
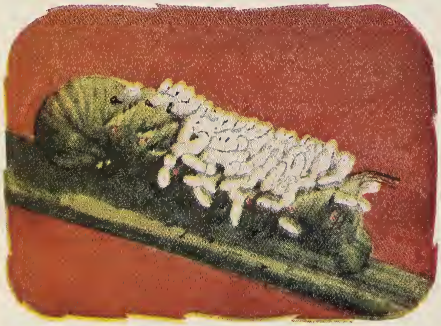
1. *How may every plant be an enemy of some other plant?*
2. *Why is it a good idea to get rid of weeds in a garden?*
3. *Why should plants not be grown too close together in a garden?*
4. *Give three ways in which plants harm other plants.*
5. *Why is it sometimes necessary to pull out some of the plants when they are growing in a row in a garden?*
6. *Tell three things you have learned about fungi.*
7. *Make a list of the ways in which plants harm animals. Give an example of each way.*

The corn that was planted near this tree cannot get the water and food materials it needs to grow. The roots of the tree are taking these materials from the soil.



How do animals harm other living things?



If you watch animals, you can easily see that they spend most of their time hunting for living things to eat. They are hunting other animals or eating plants. Most animals catch other animals, as the weasel in the picture has done. But some of the insects have another way of using other animals for food.

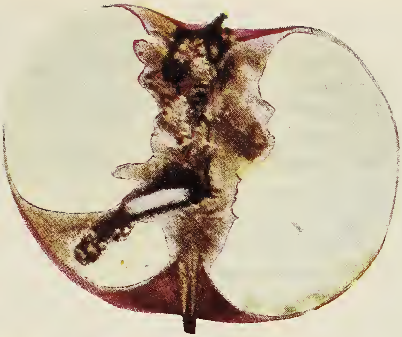
The caterpillar in the picture is being eaten by insects hatched from eggs laid on its body. A kind of fly laid the eggs on the caterpillar and left them there. When the eggs hatched, the young insects needed food. So they began to eat the caterpillar.

Many animals eat plants. Rabbits often eat the leaves of garden plants just after they have grown an inch or two. Rabbits and some other animals sometimes kill young trees by gnawing off the bark.

But as you know, rabbits and other of the larger animals are not the most dangerous enemies of plants. The most dangerous enemies of plants are the insects. Try to think how insects harm trees and other plants.

Probably you have seen leaves with big holes in them where they have been eaten by insects. You may have read how grasshoppers by the millions sometimes light on a field of wheat, oats, or corn and eat almost every plant growing in the field.

If you remember that insects go through changes as they grow, you can understand how they can damage plants in many ways. Many insects look like little worms when they first hatch from the eggs. These little wormlike creatures are called *larvae*. Each one is called a *larva*. A larva finally changes into a full-grown insect.

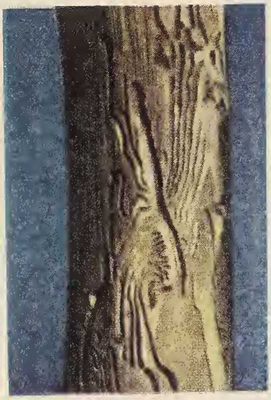


Many insects lay their eggs on the stems, roots, leaves, and flowers of plants. When the eggs hatch, the larvae eat the plants. You may have seen larvae eating the leaves of trees or of vegetables in your garden.

Did you ever bite into a "wormy" apple? The worm that you found was the larva of an insect. The larva was hatched from an egg laid by a kind of moth. This moth lays its eggs on apples. In about a week, tiny larvae hatch from the eggs and eat their way into the apples.

There are kinds of flies that ruin fruits and vegetables in much the same way that the moth larva spoils apples. They dig holes in the fruits or vegetables and lay their eggs in the holes. The larvae hatch from the eggs and eat the fruits or vegetables.

Other kinds of larvae that hatch from insect eggs eat the leaves, stems, and other parts of plants. Some of these are cabbage worms, cutworms, and cornworms. They are all insect larvae. Almost every kind of plant has some kind of larva that eats it.



Many kinds of full-grown insects kill plants by sucking the sap from the plant. You know that plants need this sap for food. When too many of these insects get on a plant, the leaves turn yellow. Then the plant dies. Other kinds of full-grown insects eat the leaves and even the wood of plants.

Look at the pictures on this page. Do you see that insects have bored holes all through the wood? These holes were made by a kind of beetle. Millions of valuable pine trees have been killed by this kind of beetle. In your social studies classes you may have heard of the cotton boll weevil. This is a kind of beetle that kills cotton plants. The full-grown beetle eats the leaves and lays its eggs on the part of the plant where the cotton grows. The larvae that hatch from these eggs spoil this part of the plant so that the cotton cannot be used.

If insects were let alone, they would soon destroy all plants in the world. Can you imagine a world without plants? You know what would happen to all of us. We would have nothing to eat. There would be no fruits and vegetables. And there would be no cows, chickens, sheep, and pigs. These animals that we use for food could not live long without plants. They need grass, corn, wheat, oats, and other plants for their food.

1. *What is the main reason why animals harm other living things?*
2. *Name five animals that you have seen harming other animals.*
3. *Name five animals that you have seen harming plants.*
4. *Why does knowing how insects grow help people fight them?*
5. *Tell three ways in which insects harm plants.*

The men in the picture on the right are harvesting hemp, grown for its fibres.

How do plants help us?

A SCIENCE CLASS once made a list of all the different plants we use for food. They named over twenty-five plants. How many can your class name? Think of all the vegetables, fruits, cereals, and nuts you eat. Every year, the people of our country eat millions of bushels of wheat, potatoes, and corn. Besides these things, we eat great quantities of apples, oranges, carrots, and other fruits and vegetables every year.

Even the tiny bacteria help us with our food supply. Some of them cause plant and animal bodies to decay. In this way, materials that plants need are added to the soil. Other bacteria are used in making vinegar and some kinds of cheese.

But food is not all that we get from plants. Suppose you look around your schoolroom. Study everything in the room. What things come from plants? Is there any rubber in your schoolroom? The rubber was probably made from rubber trees. Surely there is paint in your room. From one kind of pine tree, we get an oil used to make paint. The picture on the left on this page shows how this oil is collected. Did any of your clothes come from plants? Of course, there is wood in your room. The paper in this book was made from wood.

The rain has washed away the soil and is making little valleys on this bare hillside.

Many kinds of plants are used to make medicine. Castor oil comes from the beans of the castor-oil plant. The wonderful drug *penicillin* is made from a kind of mold.

There is another very valuable thing that plants do for us. You would probably never think of it. Plants help keep rivers from overflowing their banks. Dead leaves and stems and branches fall to the ground and make a soft, spongy covering for the soil. When spring comes and the snow melts and there are heavy rains, the water soaks down into this spongy covering. But where the soil is bare, most of the water runs off quickly into the brooks and rivers. Of course, the brooks and rivers cannot hold all this water. So they overflow their banks and flood the country. You have probably read about the great damage that is caused by floods.

Did you ever see a river in the early spring when the snow was melting, or just after a long, heavy rain? What color was the water? It was yellow or brown and muddy. Where did the mud come from? Perhaps you thought it came from the bottom of the river. But it really came from the land along the river. Rains are always washing soil into the rivers.

In some parts of North America, millions of acres of good farm land have been spoiled because people cut down trees that grew on the hillsides or plowed up the grass that grew on

Many pine trees were planted on the hillside and their roots are now holding the soil.

the prairies and plains. Then rushing water from rains and from melting snow carried the soil away from these places. When plants grew in these places, their roots helped hold the soil and kept it from washing away.

Plants keep the wind from blowing the soil away, too. Their roots form a network in the soil, and their leaves and stems slow the wind down. Not many years ago, huge dust storms swept across the continent. Strong winds blowing over bare ground picked up the dry, loose soil and carried it for hundreds of miles in great clouds of dust. Many farms were ruined, and the farmers had to move away.

Since that time, plants have been used to help prevent this loss of soil. Grass and other plants are used to cover bare soil and hold it. Trees are planted to check the wind. You can see how plants help us by holding the soil in place and helping to prevent dust storms as well as floods.

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1. *What kinds of plants did you eat yesterday and today? Name them.*
2. *What plants furnish you with clothes, rugs, curtains, and bedding?*
3. *How do plants help prevent floods and dust storms?*
4. *How do plants protect the soil?*

These men live on a sheep ranch. How are animals helping them?

How do animals help us?

If you look at things in your schoolroom, at home, and outdoors, you will find many answers to the question "How do animals help us?" Your geography book, too, will give you answers to this question.

How many different kinds of animals help furnish us with food? Our meals would be very different if we did not have cows, chickens, sheep, pigs, and fish. Animals help furnish us with clothes, too. Cows and sheep help supply our clothes. Even alligators and snakes furnish us with leather. We often use their skins for shoes, travelling bags, belts, and purses.

Animals work for us and protect us, too. Horses, oxen, camels, and even dogs carry and pull loads for us. Dogs often protect us from enemies. Cats kill mice and rats. Some of the wild animals help us, too. Skunks and snakes eat large numbers of harmful insects, mice, and rats. Many of the harmless snakes are among our best helpers and should be protected. Snakes should not be killed unless they are poisonous.

You already know how birds protect us from the insects that would soon destroy all our plants. Most hawks and owls also protect our plants. They kill rats, mice, ground squirrels, gophers, chipmunks, rabbits, and many other small animals. These animals eat the roots, bark, and other parts of our fruit trees. Or they eat the grains and vegetables from our farms and gardens.

You would probably never think of some of the other ways in which animals help us. Glue is made from the hoofs, skins, and horns of animals. Animal hair is used in plaster to help hold the plaster together. Camel's hair, the hair of squirrels, and pig bristles are used to make paintbrushes. Leather belts made from the skins of animals help run machines.

Of course, this book can tell you only a few of the ways in which animals help us. There are many more things to learn. You can discover some of them by reading, asking questions, and watching things around you. A good idea is to have a separate group answer each one of these questions and then report to the class.

1. How do animals help supply us with food?
2. How do animals help supply us with clothing?

3. How do animals help us do our work?
4. How do animals protect us against enemies?
5. How do animals help us in other ways?

The groups can help show what they have discovered by bringing pictures and samples of materials that show the different ways in which animals help us.

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1. *Name all the animals you can think of that*
    - *a) Supply us with food.*
    - *b) Supply us with clothing.*
    - *c) Help us do our work.*
    - *d) Protect us against enemies.*
    - *e) Help us in other ways.*
2. *Tell just what each of these animals does for us.*

Raising trees to hold the soil and supply lumber is one way to help with conservation.

How do we conserve the living things that help us?

DO YOU LIVE on a farm? Or did you ever take care of a garden? Boys and girls who live on farms or who have gardens know many ways in which we help plants and animals. We provide food and shelter for our horses, cows, sheep, pigs, and chickens. We even have doctors for sick animals. We are just as careful with our plants. With plows, hoes, and other tools, we loosen the soil so that air and water can get down to the roots of the plants. We put fertilizer in the soil so that the plants will have materials to make food. We spray fruit trees and other plants with poison to kill harmful insects. And we fight the weeds that rob our plants of water, food materials, and sunlight.

Did you ever hear anyone talk about *conservation*? It means protecting something or using it wisely. Everywhere in our country, men and women, and even boys and girls, are interested in the conservation of our wild plants and animals. You have already learned why we should protect some of our wild animals such as skunks, harmless snakes, and birds. Let us find out some other reasons why it is important to conserve the wild plants and animals.

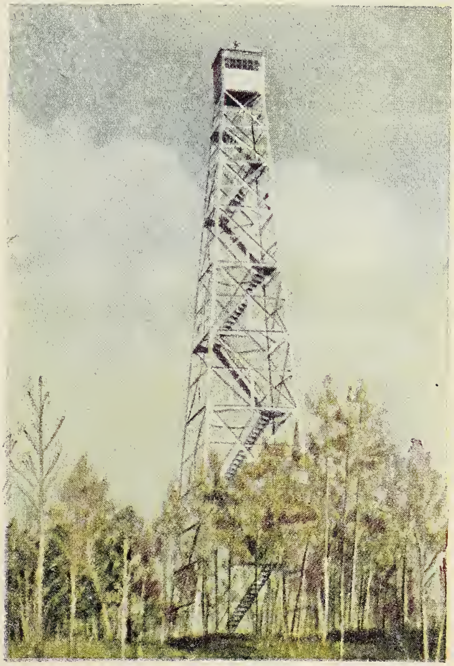
For hundreds of years, the people of our country have used plants and animals. They have cut down the trees to make houses, furniture, ships, and many other things. Millions of trees were cut down and burned so that the land could be used for farms.

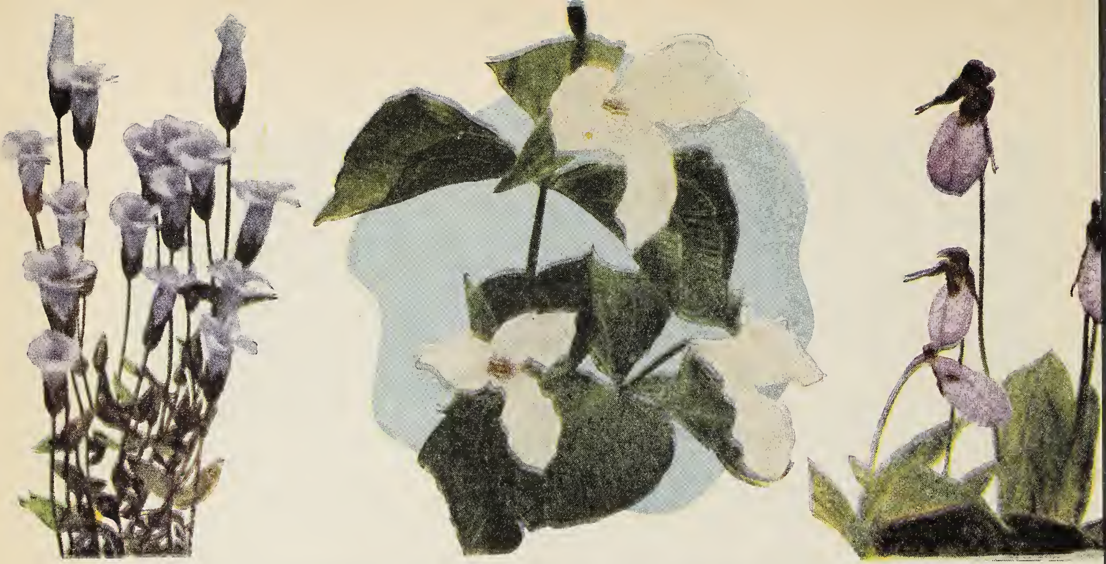
Trees are among the most important of the living things that we are now trying to save. Our governments are spending millions of dollars each year to plant new trees and to protect the trees that are already growing. Thousands of acres of land are planted with new trees each year. In many places, there are great forests where no trees can be cut. In other forests, the workmen are very careful not to harm the young trees when they cut down the large ones.

Forest fires have robbed us of millions of beautiful and useful trees. These same fires have killed thousands of wild animals. Our governments have found ways to help protect our forests from fire. On this page is a picture of a tower in one of the larger forests. During dry weather, a man stays in this tower and watches the forest for signs of smoke. He can see far over the treetops. There is a telephone in the tower. If the man sees smoke from a forest fire, he telephones to men who will find the fire and put it out.

Lightning starts many forest fires, but most fires are started by careless men and women and boys and girls. A lighted match or cigarette or cigar dropped in the grass or leaves may start a fire that will destroy thousands of trees and animals. Campers forget to put their campfires out, or they put them only partly out when they leave. The wind begins to blow, and sparks fly out into the leaves and grass. A terrible forest fire starts. Are you careful with fire when you are in the woods? Later on, you will learn how to be safe with campfires.

Every year insects destroy more trees than forest fires do. Scientists are at work in many places studying the insects that harm the forest trees. They find out where these insects live, what they eat, and other things about them. Then they work out ways of





Gentians, trilliums, and lady's-slippers are protected in many provinces. Are they in yours?

killing the insects before they do too much damage to the trees. Many thousands of trees have been saved by the work of these scientists.

You can help protect our wild plants. What do you do when you see some pretty wild flowers? Do you pick them? Or do you leave them for other people to enjoy? If you and everyone else pick the flowers, there will be no flowers for anyone to enjoy in a few years. Flowers make seeds, and seeds grow into new plants. In many provinces, laws have been passed to protect wild flowers that are in danger of disappearing. If you can, find out the names of the wild flowers that are protected in your province and learn to recognize them.

Wherever forests were cut down and bushes cleared away, many kinds of animals had no place to live. Men have also killed the wild animals and used them for food. Only about seventy-five years ago, millions of buffalo roamed the plains in the western part of our continent. Today there are only a few thousand left.

Not so many years ago in North America, there were flocks of beautiful passenger pigeons. Today not one of these birds is alive. Men killed them by the thousands, and most of the forests in which they made their homes were cut down. There used to be thousands of heath hens in the eastern part of our continent. Today there is not one heath hen left.

To help save our wild animals, we have passed laws. These laws say that some animals may be hunted only a few days every year. The laws also tell just how many animals each hunter may kill. Ducks, geese, pheasants, bears, and deer are some of the animals that are protected by laws.

Some animals have become so scarce, or they are so helpful to us, that the laws say that no one may ever kill them. In most provinces, it is against the law to kill songbirds or birds that eat mostly insects. It is also against the law to take birds' eggs.

Men and women who want to conserve our wild animals have helped them find homes for themselves. In many places in our country, there are forests and swamps where no one is allowed to kill any kind of animal. Here the birds and other animals are safe to make their homes.

You can help the birds near your home by planting trees and shrubs in which they can make their nests. You can also put up birdhouses and feeding stands. You will be surprised when you see how quickly the birds learn to come for food.

---

1. *What does* conservation *mean?*
2. *Tell three things that are being done to save our forests.*
3. *How can you help conserve our forests?*
4. *What are we doing to protect wild animals?*
5. *What is causing many of our wild plants and animals to disappear? What can you do to prevent this?*

Leaving grass and bushes around the edges of fields and along roads makes places for birds like this grouse to build their nests. These boys have raised this young deer and are letting it go in the forest.

If this bear cub could read, it would know that it is safe from hunters. The man in the other picture is catching a beaver. He wants to take it to another place where some beavers are needed to make a dam in a stream.

QUESTIONS TO ANSWER

1. Why is it important to find out what foods wild animals eat?
2. What is the most important way in which plants and animals help each other?
3. Why do animals need plants more than plants need animals?
4. Why can people use plants and animals in more ways than any other kinds of living things can use them?
5. Why do farmers plant corn, potatoes, and tomatoes in rows several feet apart instead of scattering the seeds around everywhere?
6. In some parts of the world, there are forests so thick that small plants cannot grow on the ground. Why can the small plants not grow?
7. Name some plants and animals that need our protection.

THINGS TO DO

1. Find out how these animals are helpful to us—sea gulls, skunks, snakes, and toads.
2. Write to the Dominion Department of Fisheries and find out what your province does to keep a supply of fish in the lakes and streams.
3. Read more about bees and ants.
4. Make a report to your class to show that
   - *a*) Animals cannot live without plants.
   - *b*) Plants are helped by animals.
   - *c*) People need plants and animals.

5. Make a collection of pictures that show different ways in which we use animals and plants.

6. Ask a druggist or a doctor to tell you about some of the plants that are used in medicine and some of the drugs that are made from plants.

7. Make a list of rules that we should follow to protect trees.

8. Read about the life of beavers.

9. Try to find examples of how animals live together and report what you find to your class.

10. Make some birdhouses and put them up near your home and school. Keep a record of the birds that nest in them.

11. Make a collection of plants that have been harmed by insects.

12. Write to the Department of Resources and Development, Ottawa, to get a film on forestry for your school.

13. Find out why mosquitoes made it very hard to build the Panama Canal.

14. Write to the Department of Resources and Development and find out what animals and plants are protected by law in your province.

15. Find pictures of protected plants and put them on the bulletin board. Learn to know as many of them as possible.

16. Read about the social insects called termites.

★ *In Unit Two You Will Learn* ★

★ *Why things move* ★ *Where your muscles get their energy* ★
★ *How springs get their energy* ★ *What the greatest force in the world is* ★
★ *How we use moving water* ★ *How we use moving air* ★
★ *Why steam can move things* ★ *How we use the force of explosions* ★
★ *How electric current moves things* ★
★ *How one form of energy can be changed to another* ★

⋆ UNIT 2 ⋆

What Makes Things Move?

SUPPOSE YOU wake up some morning, and nothing on earth is moving except you. You look at the clock to see what time it is. But the clock has stopped. You go into the bathroom to wash. When you turn on the tap, no water comes out. Then you have to eat a cold breakfast, because gas does not come through the pipes into the kitchen stove.

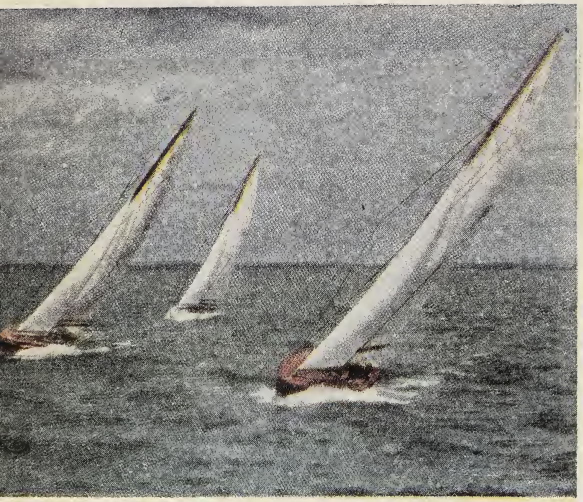
You start for school on your bicycle. When you come to the hill where you usually coast, something strange happens. Instead of coasting downhill, you have to keep on pedalling!

When you look around, you see something else that is strange. All the automobiles, streetcars, and buses are standing still. There is no wind. The air is not moving. Even the water that used to flow swiftly under the bridge is as still as can be. Nothing is moving but you!

Of course, this could not really happen, because things are always moving. Clock hands, water in taps, gas in pipes, bicycles, cars, and hundreds of other things around you all move. Do you know what makes things move? This unit will help you find out.

Why do things move?

IF YOU WANT to move a chair, you can either pull the chair or push it. Perhaps you think that lifting a chair is different from pulling it or pushing it. But if you will lift a chair, you will see that you are really pulling on it. Nothing moves unless something pulls or pushes it. Scientists have a word that means a pull or a push. This word is force. Whenever anything in the world moves, it is moved by some force.



All around you, forces are moving things. Water is flowing downhill. The trees are moving in the wind. Baseballs are thrown or batted through the air. You are walking or running to school. Automobiles, streetcars, and trains are moving on the ground. Airplanes are flying through the air. Water wheels and windmills are turning. In every one of these examples, a force is moving something.

Read over the examples. You will see that the forces which move these things are produced in different ways. You use your muscles to move yourself and other things. Automobiles and airplanes use gasoline engines. Trains use Diesel engines or steam engines. Streetcars use electric motors. Windmills use the force of moving air. Water wheels use the force of moving water.

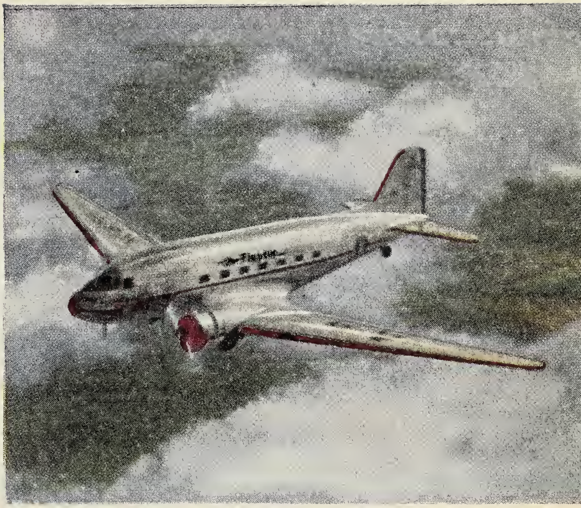
Muscles, engines, motors, water wheels, and windmills can all push or pull things. They can make other things move. They can do this because they have energy. Without energy, there would be no force.

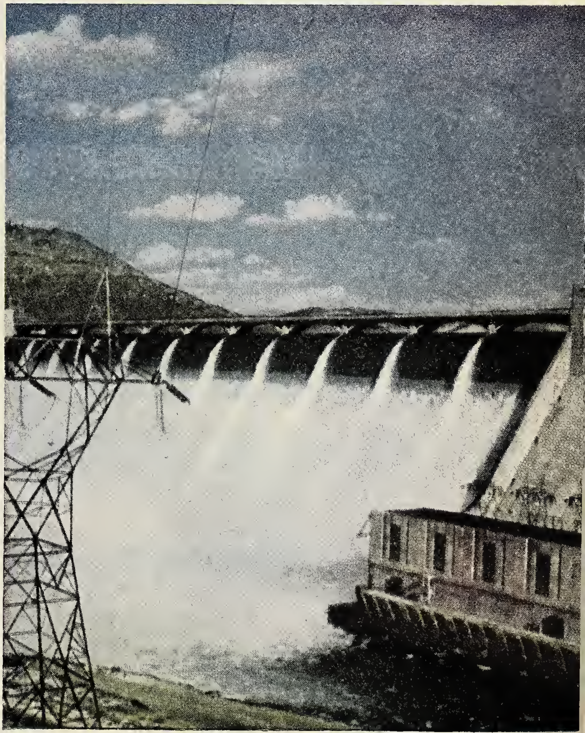
Scientists say that energy is the ability to do work. Let us see what this means. Your muscles can move your arms and legs and other parts of your body. They can do this because they have energy stored in them. You can use the energy stored in your muscles to pull back a bow. When you let the string go, the arrow will fly through the air. The bent bow can make the arrow move through the air when you let it go. It can do this because the bow has energy in it after it is pulled back.

You can use the energy of your muscles to wind a spring in a toy. When the spring unwinds, it will drive the toy across the floor. The wound-up spring has energy in it. A moving automobile has energy in it. If it strikes another car, it will move the car. The water falling over a dam onto a water wheel many feet below has energy. The moving water makes the wheel turn when it strikes the wheel. A strong wind has a great deal of energy. It can move boats or even blow a building down.

Now you can see what we mean by energy. In every example you have read where a force was moving something, there was also energy. This energy was in the muscles, the moving air, the moving automobile, the bent bow, and the water above the dam. It is the energy in all these things that makes force possible. Without energy, there would be no force. So whenever you see some force moving something, you know that this force is produced by energy.

As you can easily see, there are different forms of energy. The energy stored in your muscles is one form of energy. When an electric motor is turned on, the motor will run. Elec-





tric current makes the motor run. So electric current must have some form of energy. The energy that things have when they move is another form of energy.

As you study science, you will learn a great deal about energy and about the different forms of energy. Remember that every force is supplied by some form of energy.

Now you can probably tell what happened in the imaginary story on page 45. What must have happened if nothing moved?

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1. *What is a force? Give some examples of forces.*
2. *What do we mean by energy? How can you tell when something has energy?*
3. *Which of these have energy? How do you know?*
    - *Stretched rubber band*
    - *Moving baseball bat*
    - *Electric current*
    - *Wind*
    - *Water coming from a tap*
4. *Where does a ball get the force that will break a window?*
5. *What would happen if all forces suddenly disappeared?*

Where do your muscles get their energy?

YOU HAVE LEARNED that your body is moved by your muscles. When your muscles get shorter or longer, they move the bones of your body so that you can walk, run, play, write, lift a book, and move your body in many ways. Your muscles can move your body because they have energy.

Do you know where your muscles get the energy to pull and push and lift? If you remember what you learned about your body, maybe you can tell. And if you should go without food for three or four days, you would know where your muscles get their energy. Perhaps you have read stories of people who were lost for days without food. You know they became so weak that they could not walk or even call for help.

The energy that your muscles have comes from the food you eat. A glass of milk, an apple, and a piece of meat cannot move by themselves. But your body changes them so that they give energy to your muscles. Then your

What form of energy is being used in this picture?

muscles can move your body. And you can throw things, lift things, and make things move in other ways. Every living thing must have food, or it cannot move itself or any part of itself. Food has energy stored in it. Later in this book, you will learn where food gets its energy.

A long time ago, people did not know about the different forms of energy. The only energy that they could use was the energy stored in their muscles. After a time, they began to use the muscles of animals to help them. Animals were trained to pull wagons, carts, and plows, and to carry loads on their backs. Horses and oxen pulled plows over the fields and wagons along the roads. Even dogs were used to carry or pull loads.

Do we still use these animals to move things?

We can move things faster and more easily today because we have learned to use other forms of energy to produce forces. Then we can use these forces to move things. Later you will learn how we do this.

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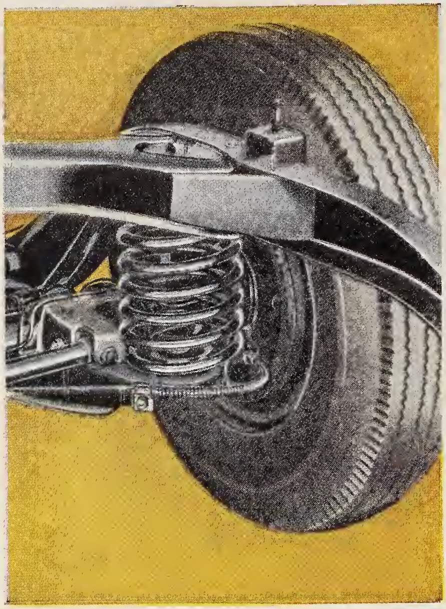
1. *Where do we get the energy that moves our bodies?*
2. *Where do animals get energy?*
3. *Does your breakfast help you ride a bicycle? Why?*

How do springs get their energy?



If you have ever played with a toy that you had to wind up to make it go, you have used a spring. Every time you wind a watch or a clock, you are also using a spring.

A spring is usually made of a flat steel ribbon or a steel wire. The steel ribbon or wire has no energy. It cannot push or pull. But if you change it in some way, the spring has energy. So it can produce a force that will make something move.

You already know one way to give a spring energy. You wind it up into a tight coil. To do this, you have to use the energy of your muscles. The energy that you use is given to the spring. When the spring unwinds, it gives back about as much energy as you put into it. Then it can make something move.

Not all springs get their energy by being wound up. Some get energy when they are pushed in or pulled out. The picture on this page shows one of these springs. It is used to give you a smoother ride in an automobile. Do you know how it does this?

Suppose the car hits a bump in the road. The wheel goes up and pushes the spring in. Then the spring pushes back and forces the wheel down. If the wheel goes down too far, the spring is stretched out. Then it pulls back and forces the wheel up.

You can find springs in many other places. A spring on a screen door pulls the door shut after you have opened it. Window shades have springs to help you roll them up. Springs in an automobile engine keep some of the other parts moving. We use springs in many ways to make things move.

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1. *How have you used springs? Give as many ways as you can.*
2. *What are you doing to a spring when you wind it up or stretch it out or push it in?*

What is the greatest force in the world?

THE GREATEST FORCE in the world is one that pulls on you and everything else. It is pulling on you now as you read this page. It pulls on the book you are reading, and it pulls on your pencil and paper. It is pulling on everything, and it keeps on pulling all the time.

You can easily see what this force does if you let go of your pencil. It will fall to the table or to the floor. As long as you hold on to it, it will not fall. But as soon as you let go of it, this force will pull it down. The same thing happens when you jump off a chair. The chair will hold you up as long as it is under you. But if you jump off, this force will pull you down. Do you know what this force is? It is called the force of *gravity.*

It is the force of gravity that pulls things down to the earth. Unless things are held up in some way, they will always fall from higher places to lower places. Rain falls from the clouds, apples fall from trees, and balls thrown high in the air always fall back to the earth again. The force of gravity is always pulling on things. If you want to keep a thing from falling, you must hold it or put it on something.

The force of gravity pulls you and your wagon or sleigh downhill. When

What force is pulling these children downhill on their skis and sleighs?

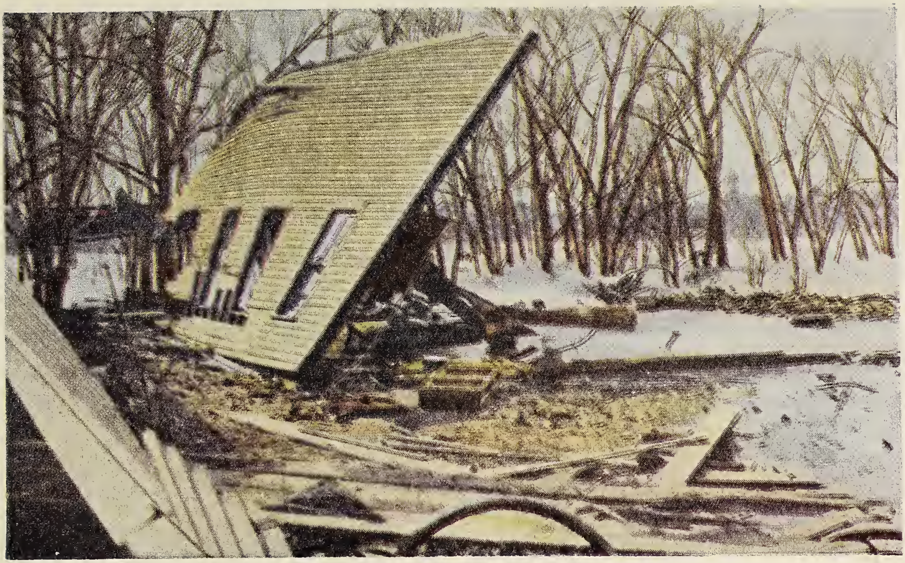
you have pulled it up the hill, you point it toward the bottom and then sit down on it. Someone gives you a little push, and away you go! Gravity is pulling you faster and faster until you get to the bottom of the hill.

Aviators who have to get out of their planes when they are in the air, use gravity to get themselves down to earth. But gravity would pull them down too fast unless they used a parachute. Later in your study of science, you will learn how a parachute works.

Do you know how much the force of gravity pulls on you? There is an easy way to find out. All you need to do is weigh yourself! The pull of gravity on you is your weight. When you weigh anything, you are really measuring the pull of gravity on it. We use scales to weigh things, and we measure their weight in pounds.

---

1. *Name the things in your schoolroom that are pulled by the force of gravity. Remember that anything that has weight is pulled by gravity.*
2. *How many of these things are pulled by the force of gravity?*
   Feather Rock Noise Pail of water Sunshine
3. *Why does the water sink into the ground after a rain?*
4. *When you weigh yourself, what are you finding out?*
5. *Which of these sentences is not correct?*
   - a) *Gravity makes rivers flow.*
   - b) *Gravity does not pull on a book if the book is on a table.*
   - c) *Rain falls because gravity pulls it.*
   - d) *Sleighs go downhill because snow is slippery.*
   - e) *Gravity pulls on everything all the time.*



How do we use moving water?

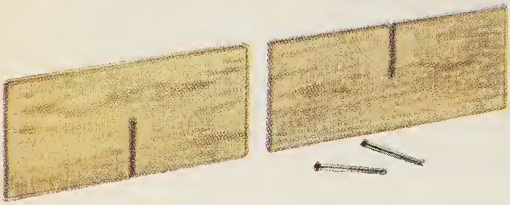
If you have ever stood in a swift stream of water, you have felt the force of the water as it raced past you. Perhaps it had enough force to push your feet out from under you. Moving water is another force that people learned to use long ago.

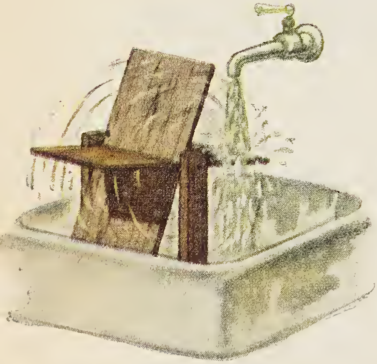
Terrible floods show us that moving water has great force. On this page, there is a picture of a building that was wrecked by a great flood of water. Do you see what happened to the building? It was lifted up, tipped over, and smashed by the force of the water. Mud and parts of other buildings were carried by the water.

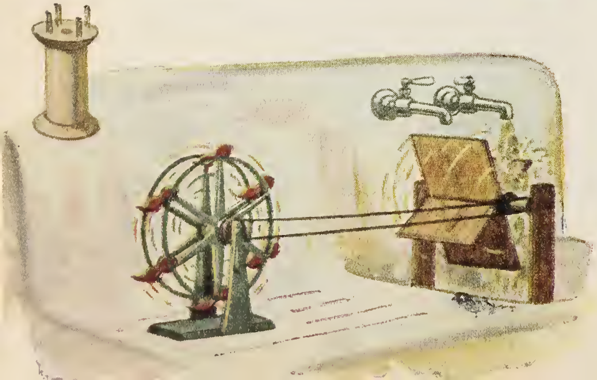
But the force of moving water does not always do harm. On the next page there is a picture that shows how people have learned to use the force of moving water to run a machine in a mill. Can you see what makes the water wheel go?

It is turned by the force of the moving water in the stream. The water moves against the paddles of the wheel and pushes the wheel around. When the wheel turns, it moves a machine in the mill. The machine grinds corn into meal and wheat into flour. The miller is using the force of moving water to do his work.

Some kinds of water wheels are used to turn machines that produce electric current. The water strikes the paddles of the wheel, and the







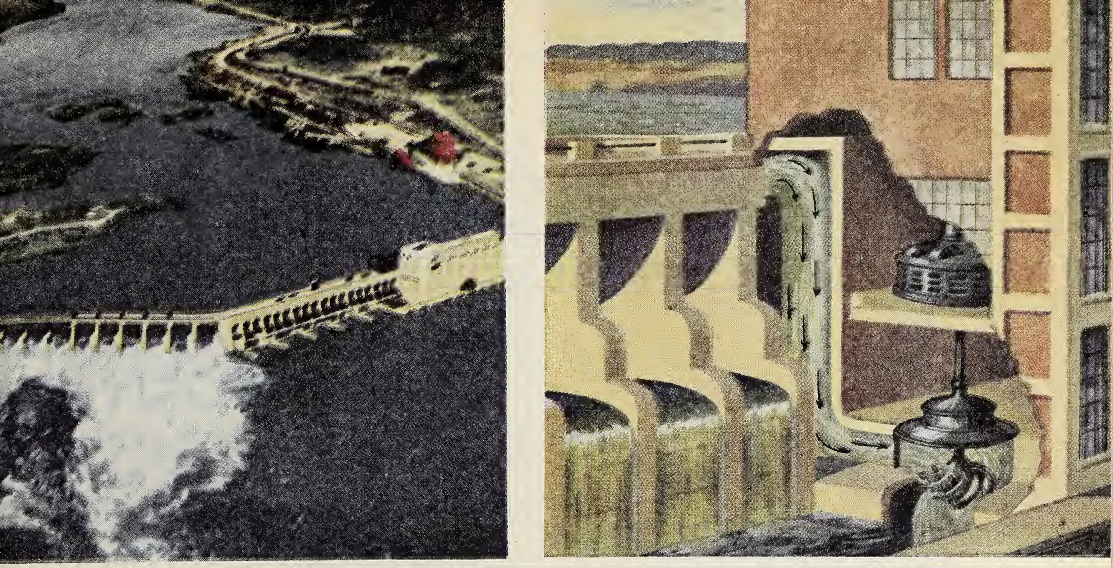
wheel turns the machines. Perhaps the electric current that lights your home and school is produced when water moves a water wheel.

You can easily understand how the force of water can make things move if you make a water wheel and watch it turn. Look at the pictures on this page. They show a kind of water wheel that you can make. Get a thin board and cut it into pieces to make the paddles. Then fasten the paddles together as they are in the picture. Put the nails through the holes in the support and hammer them into the paddles.

When the wheel is finished, hold it under a tap and let the water fall on the paddles. Does the wheel turn? Open the tap wider so that the water will run faster. Does the wheel turn faster? When the water runs faster, it has greater force. And when the force is greater, the wheel turns faster.

If you have made your water wheel carefully, you can use it to turn another wheel. Slip a small spool over one of the nails and fasten it to the paddles. Look carefully at the picture. You will see how the spool is connected with the small wheel on the toy Ferris wheel by a strong piece of string. Now you can see how the force of moving water can be used to make machines go.

The water that turns a water wheel would never move unless something



The picture on the left shows a big dam. At the right, you see the inside of the building where the water that falls over the dam turns the water wheel.

pulled it or pushed it. It is pulled by the same force that pulls your wagon or sleigh downhill. This force, you remember, is gravity. The force of gravity makes water run from high places to lower places everywhere on the earth.

When people built a mill near a waterfall, they used the force of gravity to turn the water wheel. The water from the top of the falls flowed over the top of the water wheel. The wheel had buckets around its rim. The water fell into the buckets, and the weight of the water in the buckets made the wheel turn.

People often make the water in a stream rise to a higher level so that when it falls, it will have greater force. To do this, they build a dam across the stream to hold the water back. The water from the top of the dam falls swiftly down through a big pipe. At the bottom of the pipe, there is a water wheel. The water falls on the water wheel with a great deal of force and makes the wheel turn fast.

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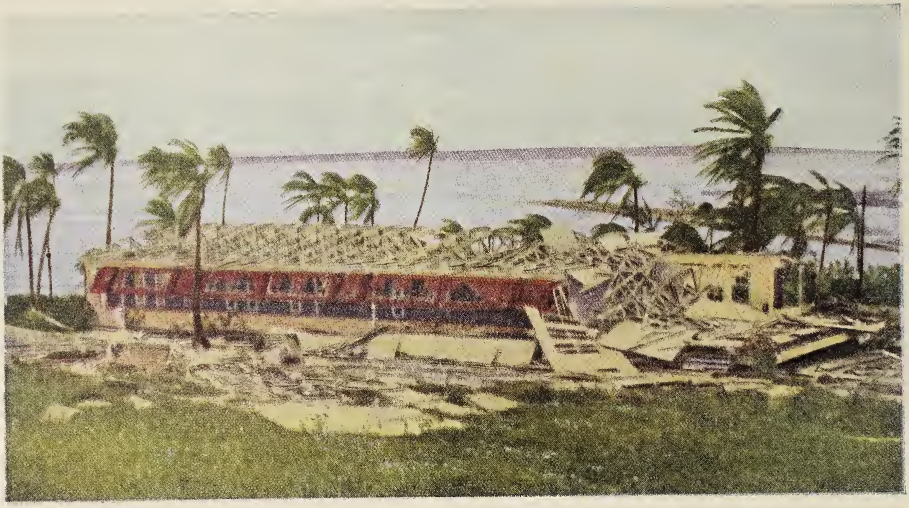
1. *Which water wheel will turn faster, one that is in a stream flowing down a mountain or one that is in a stream on almost flat land? Why?*
2. *Why were factories often built near rivers?*
3. *Do you think that moving water has energy? Explain your answer.*
4. *How is gravity put to work by water wheels?*

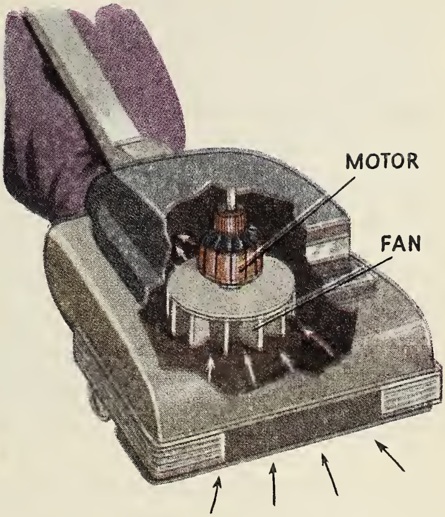


How do we use moving air?

THE FORCE of moving air did all the damage in this picture. The moving air was a very strong wind called a *hurricane.* Do you see that the roof of the building was torn off and that some of the walls were blown down? Do you think that the air still had much force when the picture was taken? How do you know?

Sometimes strong winds blow across dry fields. They lift the fine bits of soil into the air and make huge dust storms. Much good farm land has been ruined in this way. The force of the moving air may carry thousands of tons of soil for hundreds of miles before the dust settles to the earth again. Of course, a gentle wind has not as much force. It may move only the leaves of the trees or blow dust into your home.

The first way people used the force of wind was to make their boats move on the water. Long ago, before people knew how to make engines, many boats were pushed by the wind. These boats had big sails on them. When the wind blew over the water, it pushed against the sails and moved the boats along. If the wind blew hard, the boats moved fast. But if the wind blew gently, the boats just drifted slowly along. The force of wind is also used to push boats over the ice. The wind sweeps over the frozen lake, pushes against the sails, and sends the iceboats sliding over the smooth ice at great speed.



You may want to make a sailboat and take it to a pond to let the wind sail it. Another thing you can do is to make a pinwheel. If you fasten it on the window sill or on the top of a fence, the force of the wind will keep it turning much of the time.

Moving air can push against things with great force. But the air is not always moving. Sometimes the wind blows, and sometimes it does not. You would probably like to know what makes the wind blow. Some force must make the air move. This force is gravity. Later on, you will find out how gravity makes air move.

Sometimes we make air move by using fans. A vacuum cleaner is a machine that works by using moving air. Here is a picture of the inside of a vacuum cleaner. Do you see the fan? An electric motor turns the fan, and the fan makes air rush into the cleaner. If you put your hand near the opening of the cleaner, you can feel the push of the air as it rushes in.

When the cleaner is pushed across a rug, the air rushes in with so much force that it carries the dust and dirt along with it. The air goes out through the bag of the cleaner, but the dust and dirt cannot get through. They stay in the bag.

You already know that we can make air move by using fans as in a vacuum cleaner. People sometimes use air to move things through pipes. In some factories, fans blow air through big pipes. Cotton, wool, and other light materials are put in the pipes and moved from one part of the factory to another by rushing air.

If you live on a farm, you have probably seen a threshing machine. It separates the grains of wheat or oats from the straw. Then a big fan sends air through a long pipe to blow the straw out onto a big pile. In the picture at the left on this page, you can see the straw being blown out of the pipe. The other picture shows how the force of moving air is used to keep a tank filled with water so that the cows can drink. The wind turns the wheel of the windmill. The wheel works a pump that brings water up from a well. People have used the force of wind to run windmills for hundreds of years.

Moving air is like moving water. We can use its force to make many things move.

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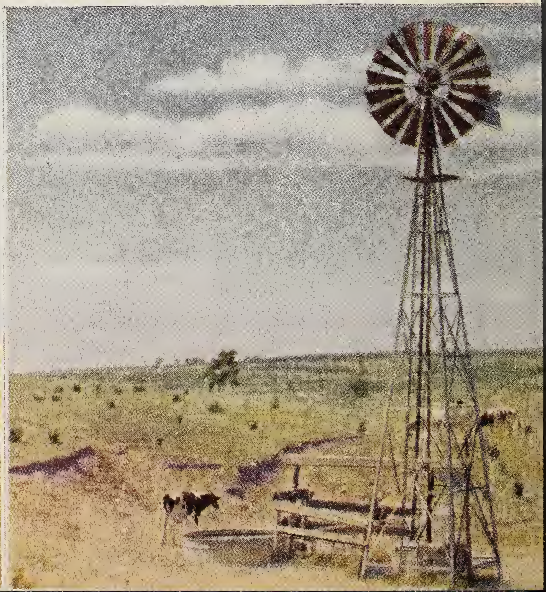
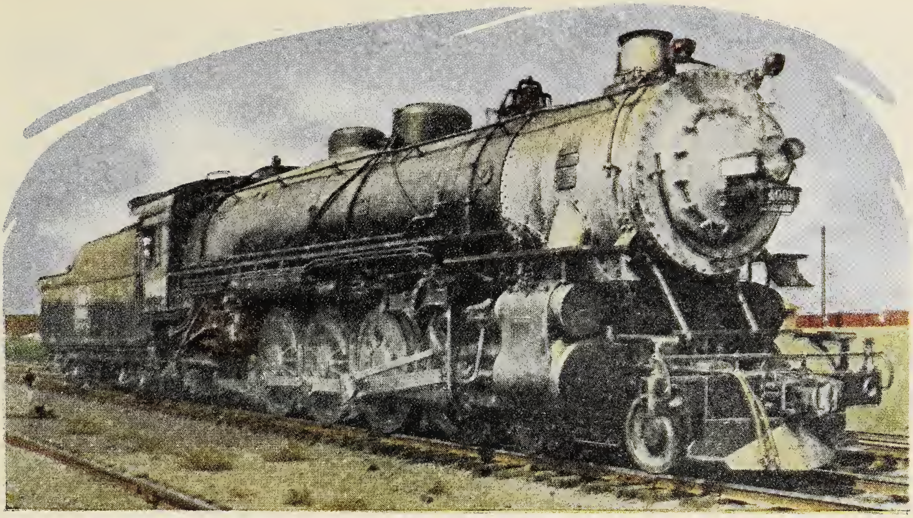
1. *In which of these ways is the force of moving air like the force of moving water?*
    - *a) It may be very strong.*
    - *b) It may be used to help us.*
    - *c) It may cause damage.*
    - *d) The faster it moves, the more force it has.*
    - *e) It can move very heavy things.*
2. *If you wanted to get to a place at a certain time, would you rather take a boat that is run by an engine or one that is moved by the wind? Why?*
3. *What makes the air move in a vacuum cleaner?*
4. *How do we use the force of the wind?*





Look carefully at the pictures on this page and the next one. They will help you understand how a locomotive is made.

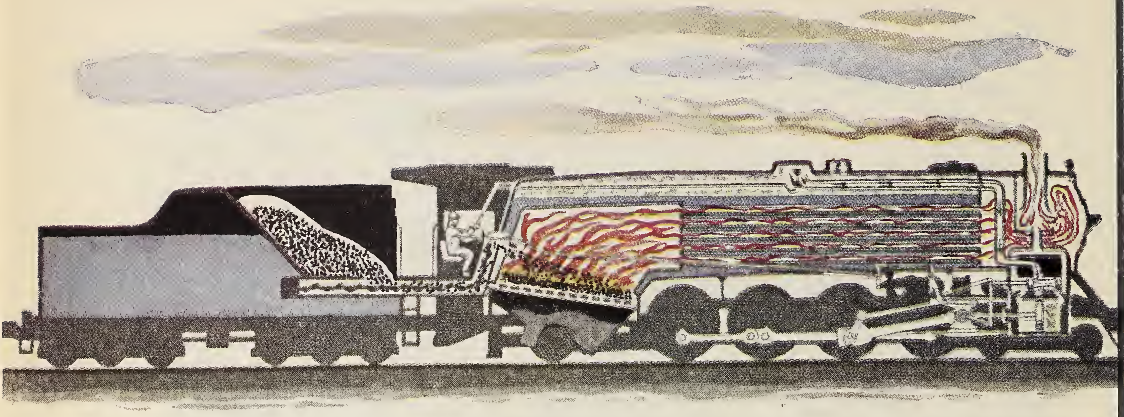
Why can steam move things?

MANY TIMES you have seen a long train of railroad cars pulled by a puffing locomotive. You know that the locomotive is called a steam engine. What force moves the engine and the long, heavy train of cars? It is the force of steam. Long after people learned to use the forces of moving air and water, they discovered how to make steam move things. When they learned how to use its great force, they could do many things that they could never do before.

Do you know where steam comes from? It comes from water. But before water can make steam, it must be heated. When water gets hot enough, it boils and changes to steam. Steam is a gas. Like air, steam is colorless. You cannot see it at all!

Probably you have watched a teakettle in which water was boiling. Steam filled the kettle and then began to come from the spout. If you looked close to the spout, you saw a little clear space. In this space there was steam. Beyond this space was a white cloud. You probably call this cloud "steam," but it is really water.

When a teakettle is full of boiling water, steam is sometimes made faster than it can get out of the spout.



Most of the locomotive is used to hold the water and the fire. Can you find the pipe that carries the steam from the boiler to the part that moves the wheels?

Then the lid of the kettle pops up and down. The force of the steam makes the lid move. An easy way to understand how steam can move things is to do this experiment.

Fill a test tube about half full of water. Put a cork in the top of the test tube. Be careful to set it lightly in the opening. *Do not push the cork in tightly.* Now heat the test tube gently. *Keep the cork pointed away from your face and away from anyone who is watching you.*

As the water boils, it changes to steam. The steam quickly fills the test tube. The water keeps on changing to steam. The steam crowds against the sides of the tube and also pushes against the cork. At last, there is so much force against the cork that it shoots off into the air. If the cork had been pushed tightly into the test tube, the force of the steam would have burst the glass into pieces.

But why has the steam such great force? When water changes to steam, it makes a great deal of steam out of a small amount of water. If one quart of water is all changed to steam, how many quarts of steam do you think it makes? It makes 1600 quarts!

It is easy to see that 1600 quarts of steam will push hard in all directions if you try to keep it all in the same space that a quart of water takes up. You have seen the same thing happen when you pump air into a bicycle tire. The more air you pump into the tire, the harder the tire becomes.

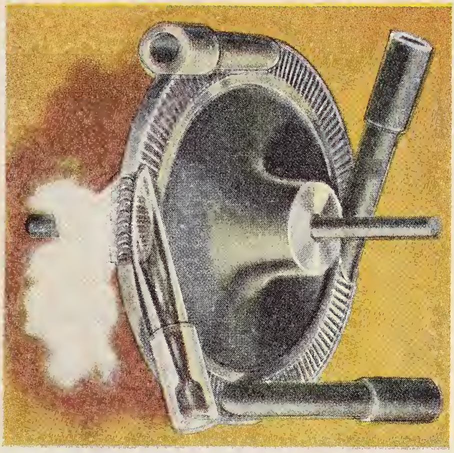
Every steam engine has a boiler for water and a fire to change the water to steam. Pipes carry the steam to the engine. The energy that a steam engine uses comes from coal, oil, or other fuel.

Fuel is like food because it has energy stored in it. When the fuel burns, it gives off heat. Heat is energy, too. It can change water to steam. The steam can push against a part in the engine and make it move back and forth. Then the engine turns wheels to make something move.

The next time you see a steam locomotive pulling a long train of cars, you can say to yourself, "Steam gives the force that is pulling all of those cars. The coal is burning, and the heat from the burning coal is changing the water to steam. The steam is pushing hard to get out. This push makes the wheels of the locomotive turn. The locomotive is just a machine for using the force of steam to move trains for us."

Another kind of steam engine turns like a water wheel or a windmill. Pipes carry steam from a boiler to a wheel. The rushing steam pushes hard against blades in the wheel, and the wheel turns very fast.

The picture above shows how this kind of steam engine works. Of course, this is just a small one. Many of the steam engines like this that run ships and power plants have many rows of blades. There may be thousands of blades. The steam pushes against all these blades so that the wheel turns very, very fast.

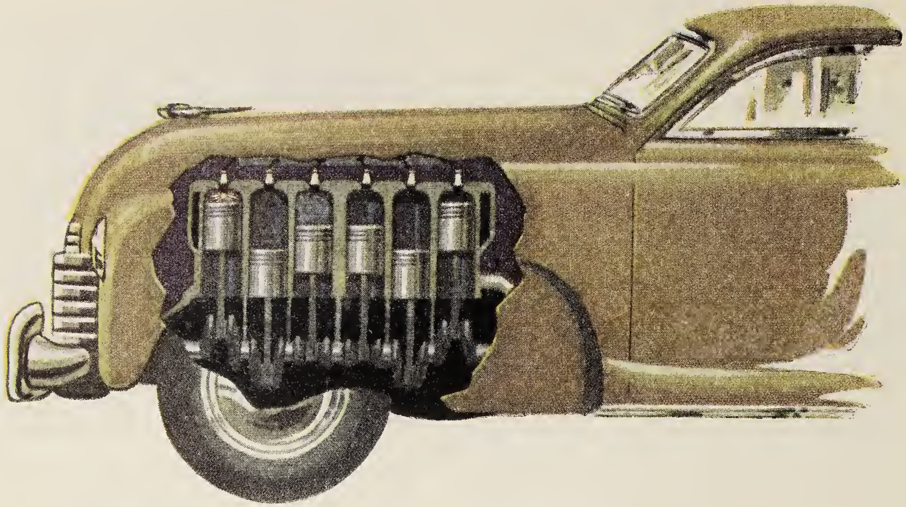


This wheel is turned by the force of the steam that comes out of the pipe and hits the blades of the wheel.

Steam engines are used to pull trains, to make ships move, to run big scoop shovels, and to turn the wheels of machines in many power plants and factories.

---

1. *What two things must a steam engine have so that it can get steam to make it move?*
2. *What makes water turn into steam?*
3. *Is steam a solid or a liquid or a gas? Can you see steam?*
4. *Why did steam push the cork out of the test tube?*
5. *What does steam do in an engine?*



The engine of an automobile looks somewhat like this. Look for the parts where the gasoline explodes.

How do we use the force of explosions?

DID YOU EVER travel on the force of an explosion? You may think that is a very strange question. But probably every boy and girl in your class has travelled on the force of explosions many times!

Whenever you ride in an automobile, you are being moved by the force of an explosion. Gasoline explodes inside the engine and makes the automobile move. Like coal or any other fuel, gasoline has energy stored in it. The force of the explosion comes from this energy in the gasoline. Now let us see what makes the gasoline explode.

We put gasoline into a tank on the automobile. When it is put into the tank, the gasoline is a liquid. It flows through a pipe to the engine. Then it goes through a part that changes it to a fine spray. Air is mixed with the spray, and the gasoline changes to a gas. Then the gas goes into another part of the engine. Here a tiny electric spark explodes the gas.

When anything explodes, it suddenly gets very much larger. It pushes out in every direction with great force, just as steam does. This great force can make something move. When gasoline explodes in the engine of a car, the force of the explosion moves parts of the engine. Then the wheels turn, and the automobile moves. A gasoline engine is just a

This streamlined train, which can go very fast, is pulled by a Diesel engine.

machine that is run by the great force of exploding gasoline.

Another kind of engine also runs by the force of explosions. It is called a Diesel engine. For fuel, it uses oil instead of gasoline. And no spark is needed to make the oil explode. Many ships and trains use Diesel engines.

The force of exploding gas can carry you over the roads at high speed. It can also move big, heavy trucks and boats and pull plows through the soil. It can run the engines that make airplanes fly. What a different world this would be if we did not have the force of explosions!

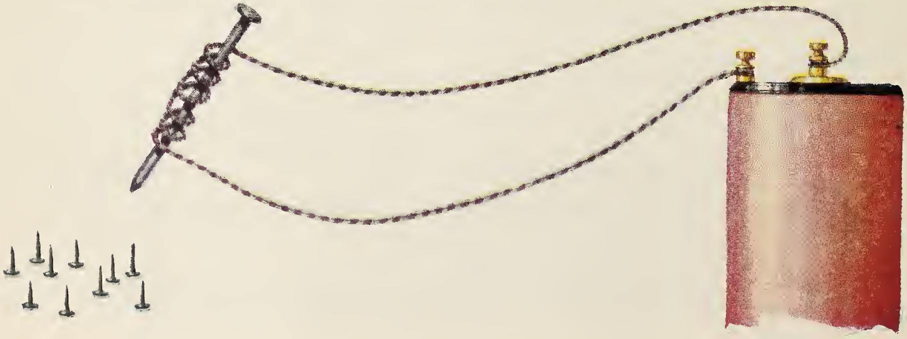
---

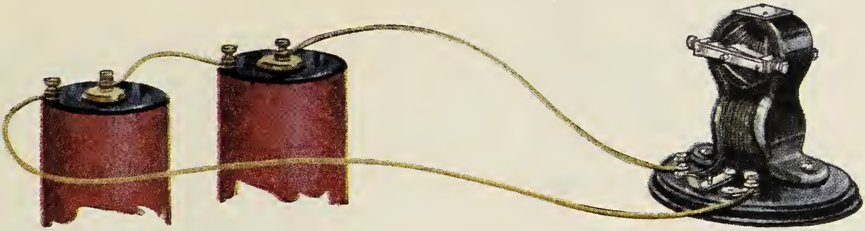
1. *What word is needed in each sentence?*
    - a) *Gasoline is a__________when we put it into the tank.*
    - b) *Gasoline is a__________when it explodes.*
    - c) *When gasoline explodes, a great__________is produced.*
    - d) *Exploding gasoline has force because it gets__________.*
2. *How are steam and gasoline alike in the way in which they produce force? How are they different?*
3. *What makes the gasoline explode in an automobile engine?*

HERE IS A PICTURE of a boy who is using the energy of electric current. His father gave him an electric train for Christmas. It must have something to make it move. The track is connected with an electric outlet by a long cord with wires in it. Inside the engine is an electric motor. When the boy turns the electric switch on, an electric current will flow through the wires, through the track, and into the motor of the toy engine. The motor will turn and move the engine that pulls the train. When he turns the switch off, the electric current stops flowing. The motor no longer turns, and the train stops.

This experiment will help you understand how a motor works. Get a large iron nail. Wind about twenty turns of cotton-covered copper wire around the nail. Now connect the two ends of the wire to an electric *cell,* as shown in the picture below. Try to pick up some tacks with the nail. Is the nail a magnet? What happens to the tacks on the nail when you disconnect one wire from the cell?

The experiment shows that an electric current flowing through a wire around a nail will make the nail into a magnet. When the current is stopped, the nail is not a magnet.





You can make a motor turn by connecting it to some electric cells.

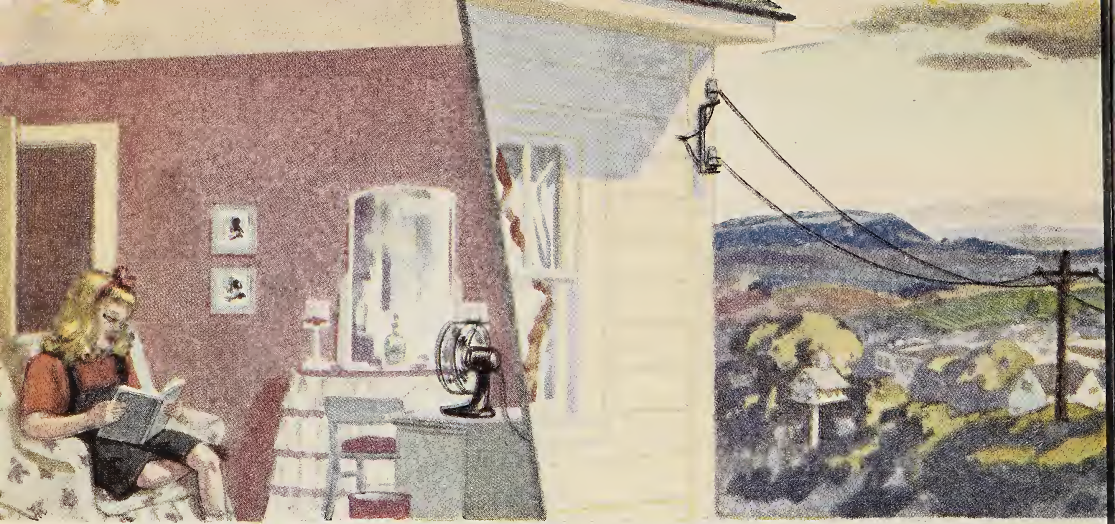
Look at the picture of the motor. The frame of the motor is made of iron. The two sides of the frame are connected at the bottom with a piece of iron. It has some wire wound around it. When an electric current flows through the wire, the frame becomes a magnet. Magnets, as you remember, have poles. One end of the iron frame is a north pole or N pole, and the other end is a south pole or S pole.

Now look at the part that turns inside the frame. It is made of iron, too. It also has wire wound around it. When an electric current flows through the wire, this part becomes a magnet, too.

When you studied magnets, you learned that *like* poles always *repel* each other and *unlike* poles *attract* each other. Try this experiment. Tie a string around a bar magnet and hang it from a wooden support. Hold another bar magnet in your hand and bring the end marked N near the N pole of the hanging magnet. What happens? Now, as the magnet turns halfway around, bring the S pole of the magnet in your hand near the S pole of the hanging magnet. If you keep on doing this, you can make the hanging magnet turn round and round.

An electric motor works in the same way. The electric current makes the frame a magnet, and it also makes the part that turns inside the frame a magnet. This part keeps turning as the like poles of the two magnets repel each other and the unlike poles of the two magnets attract each other. If you have a small electric motor, you can connect it to some cells to make it run. Look at the picture on this page. It shows you how to connect the cells and the motor.

Your mother may use electric current to keep your clothes clean. She does if her washing machine is run by an electric motor. If her sewing machine is an electric one, there is a motor to move the needle up and down when she sews. There is a



The energy of moving water is keeping Betty cool! If you look at these pictures and read the next page, you will see how this can be true.

motor in her vacuum cleaner. If you live in the city, you may ride on streetcars run by electric motors. If you live in the country, you may use a motor to pump water from the well up into a big tank.

People have invented a machine that makes electric current flow through wires. This machine is called a *generator*. A generator may be run by water wheels, steam engines, gasoline engines, Diesel engines, or by the wind. Look at the pictures on page 55. The water wheel at the bottom of the dam is running a generator that makes electric current flow. In the picture on page 68, the generator is run by the wind. In an automobile, there is a little generator for making electric current flow. The current from this machine makes the spark that explodes the gasoline.

The second way of making electric current flow is with an electric cell. When we connect two or more cells to get current, we say that we have an electric *battery*. When you push down on the starter of an automobile, an electric current from a battery runs a motor. This makes the automobile engine turn until the gasoline begins to explode and run the engine. The cells of the battery have energy stored in them. This energy makes an electric current flow when the battery is connected to a motor. The electric current has energy that gives the force to turn the motor.

---

1. *What are two ways to make electric current flow?*
2. *How do we know that an electric current has energy?*
3. *Name some machines that are run by electric motors.*

The electric current that comes from the generator goes through several wires before it comes into Betty's house.

How can one form of energy be changed to another?

DO YOU BELIEVE what it says under the pictures on page 66? Of course, there is no moving water in that picture. Then how can Betty be using the energy of moving water?

The electric fan is moving the air around Betty. It is moving her dress, the window curtain, and even her hair. This moving air is keeping her cool. Would you believe that Betty is being kept cool and that her dress is moved by the energy of moving water?

Betty's home is a few miles from a river that has a big dam in it. The rushing water falls over the dam and runs generators that make electric current flow through wires. The current flows through several wires until it comes to Betty's house.

Betty has connected the electric fan to the electric outlet in her room. This connects the fan with the wires that carry the electric current from the generators. Inside the fan is an electric motor. The energy of the electric current gives the force that makes the motor turn. The turning motor moves the fan. The whirling fan blades strike the air and make the air move. So you see how Betty is being kept cool by the energy of moving water.

This shows you a very important thing about energy. One form of energy can be changed into another form of energy. This change of energy from one form to another is taking place all around you. What are some ways in which it is happening?

If you read this unit over again, you will find many examples of this change of energy. In your body, the energy stored in food is changed into the energy your muscles have.

The energy of moving water can be changed into the energy of electric current. So can the energy of moving air, as shown in the picture. This wind generator can make enough electric current for a farm.

When a steam engine moves, it is using the energy in steam. This comes from the energy stored in coal, oil, or some other fuel. When the fuel is burned, it gives off heat. Heat is also a form of energy.

An automobile engine gets its energy from gasoline. The stored energy in the gasoline is changed into a form of energy that can move the car. This happens when the gasoline explodes in the engine.

Whenever you see something move, you can be sure that somewhere some form of energy is producing the force to make it move.

---

1. *How could explosions keep you cool?*
2. *How could a coal fire keep you cool?*

QUESTIONS TO ANSWER

1. Which of these helps you most in your home? Moving air, electric current, steam. What are the different ways in which it helps you?

2. How are moving water, steam, electric current, and moving air all alike?

3. How does the force of gravity help us? How does it hinder us?

4. Which of all the forms of energy do you think helps us most? Why do you think so?

5. How do these men use the forms of energy you have learned about? A dentist, a farmer, a railroad engineer, an automobile repairman.

6. Study the picture on page 58. What forces are being used?

THINGS TO DO

1. Visit a place where water is being used to make electric current. Find out where the water wheel is.

2. Find out how many forms of energy your father uses to do his work.

3. Find out what form of energy is used to produce the electric current in your home or town.

4. If you have a toy steam engine, bring it to school. Run the engine to show that steam has force.

5. Write a story that tells how the world would be different if electric current, steam, gasoline, and moving air did not have force to make things move.

6. Make a list of things that you have seen being moved in the last few days.

7. People move things by exploding other materials besides gasoline. Find out

a) How big blocks of stone are broken loose in stone quarries.

b) What makes a bullet shoot out of a gun.

8. If you can, look at a steam locomotive and find out how the force of the steam is used.

★ In Unit Three You Will Learn ★

★ *What a machine is* ★ *How we use levers* ★ *How we use inclined planes* ★ *How we use pulleys* ★ *How we use a wheel and axle* ★ *How one wheel can turn another wheel* ★ *How we can make machines work better* ★ ★ *How we can use machines safely* ★

⋆ UNIT 3 ⋆

How Is Our Work Made Easier?

One stormy night, Jack was suddenly wakened by a loud, cracking noise. Then he heard something crash outside in the yard. Jumping out of bed, he ran to the window. It was just beginning to get light. There on the ground he could see a big tree lying across the driveway to the garage. A strong wind had blown it down.

"Well," said Jack's father as they looked at the tree that morning, "I can't get the car out until the tree is moved. It's too heavy for us to do. I'll have to get some men to move it."

"How can they move a big, heavy thing like this?" Jack asked. "It will take a lot of men to lift it. And if they try to drag it off, the branches will ruin our lawn."

"Wait and see, Jack," laughed his father. "The men will probably be here this afternoon."

That afternoon, Jack hurried home from school. The men were already working. It was fun to watch them. First, they chopped off all the branches with axes. Next, they used a big saw to cut the tree into short logs. Then with wedges they split the logs into smaller pieces. Jack could lift some of these pieces himself. He helped the men pile them up.

Now Jack saw how a few men could move a big, heavy tree. They used tools to make their work easier. Tools are helpers. They help us make better use of the force of our muscles and of the other forces you read about in Unit Two. Many times every day, we use tools and other helpers in our work. Scientists have a name for all these helpers that we use. They call them *machines*. In this unit, you will learn why many things you use are called machines.

What is being done in these pictures? How could these things be done more easily?

What is a machine?

WHEN YOU THINK of a machine, you probably think of something like an automobile or a locomotive. They are machines. But a hammer or even a can opener is just as truly a machine as a locomotive or an automobile. You may be surprised to learn that all of these things are machines—orange squeezer, knife, wheelbarrow, broom, windmill, scissors, egg beater, pencil sharpener, bicycle. Can you tell why each one is a machine?

A hammer, a pencil sharpener, and a bicycle do not look alike. Machines have many shapes and sizes, but there is one way in which all machines are alike. Every machine can be used to make our work easier. A machine is a helper. We use machines to do a great deal of our work. They help us cut, mix, bend, straighten, lift, push, and pull things.

We can do many things with machines that we cannot do without their help. Men could not break a big tree into small pieces with just the force of their muscles. But with axes, saws, and wedges they can easily do it. Machines make work easier.

You can see this for yourself. Cut an orange in two and squeeze the juice out of one half with your hands. Was it easy to do? Did you get out all the juice? Now use an orange squeezer to get the juice from the other half. Was it easier to do this time? Did you get out more juice? The orange squeezer made your work easier, and it helped you do a better job.

Big machines and even some little machines are made of many parts. You know that locomotives, automobiles, bicycles, watches, and sewing machines have many parts. But do you know that all these machines are made of a few kinds of *simple machines* put together in different ways? In each simple machine, there are only a few parts.

If you could take a watch, an automobile, or an airplane apart, you would find the same kinds of simple machines in each one. Let us see what these simple machines are and find out how they make our work easier.

---

1. *Why do we use machines?*
2. *Name as many different machines as you can and tell how each one helps us.*

How do we use levers?

DID YOU EVER play on a seesaw? You sit on one end of a long board, and another boy or girl sits on the other end. In the middle, there is a support that holds the board up. To make the seesaw go, you push against the ground with your feet. This push lifts your end of the board and makes the other end go down. Then the other child pushes with his feet, and so on. In this way, you can keep going up and down.

You probably noticed that the seesaw works better if you balance the board first. This is easy to do if both of you weigh about the same. Each one sits at the same distance from the support in the middle of the board. Gravity pulls down on each of you with about the same force, and the board balances. It takes only a little push with the feet to make the seesaw go.

But what happens if one of you weighs much more than the other? Gravity pulls with more force on the heavier child. His end of the board comes down with a bump, and the other end flies up. To make the seesaw go, the heavier child has to push hard with his feet. The other child does not have to push at all.

Do you know how the lighter child can lift the heavier child and make

the board balance? If there is a seesaw on your school playground, you can easily find out. Have a heavier child sit on one end of the board while you sit on the other. What happens? Now you move closer to the support in the middle. Can you lift the heavier child? Sit on the end of the board again. Then have the heavier child move closer to the support. What happens this time? Can you lift the heavier child now?

A seesaw is really a simple machine. Scientists call this kind of simple machine a *lever*. The board of a seesaw is held up by a support. This support is the *fulcrum* of the lever. Of course, most levers are not just playthings like a seesaw. We use them to make our work easier.

You can easily make a lever and do some experiments with it. Then you can see why a lever is such a useful helper. Get a board about three feet long and three inches wide. Use a small, three-sided block of wood about two inches high as a support for the board. This support is the fulcrum of the lever.

First, see if you can use this lever to make a light book lift a heavier book. Set the board on the block so that there is twice as much of the board on one side of the block as there is on the other side. One end of the lever should be one foot long and the

other end two feet long. Put the heavy book on the short end. What happens to the other end of the lever? Now set the light book on the long end of the lever. Does it lift the heavy book? Which book is closer to the fulcrum?

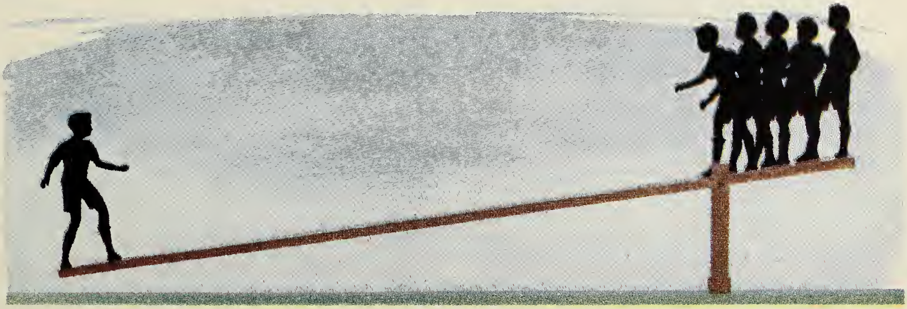
Try another experiment with the lever. Get two small boxes of the same size. Fill one box with sand, stones, or anything heavy until it weighs two pounds. Set the lever just as you had it before. Put the box that weighs two pounds on the short end. Then set the empty box on the other end. Put sand or stones in this box until it lifts the other box.

Take the box off the long end of the lever. How much does this box weigh? Is it lighter or heavier than the two-pound box? Which box was closer to the fulcrum? What does this tell you about using a lever?

You know that the weight of anything is really the force with which gravity pulls it down. We measure this force, called weight, in pounds. And we can measure any other force in pounds, too. When you lift a two-pound box, your muscles must pull up with a force of two pounds.

In the experiment, you found that the box on the long end of the lever weighed about one pound. So a force of one pound on the long end of the lever lifted a weight of two pounds on the short end. The weight was closer to the fulcrum than the force was. The lever increased the force.

Look at the picture below. One boy is lifting five boys. How can he do it?



How are these people using levers to help them?

A lever is very useful, because a small force on the long end will lift a much heavier weight on the short end. The lever increases the force. But did you notice another thing? It changes the direction of the force, too. With this lever you can lift something up by pushing down! It is easier to push down than to pull up.

Do you see why this is true? When you push down, the force of gravity is added to the force of your muscles. But when you pull up, the force of your muscles must pull against the force of gravity.

By using a lever, you can do things that you could not do at all without it. Drive a nail or a tack part way into a board but leave the head sticking out. Take hold of the head with your fingers and pull as hard as you can. Did the nail or tack come out of the board? Now use a claw hammer or a tack puller. Do you see how easy it is to pull the nail or tack? A claw hammer or a tack puller is a lever. The place where it rests against the board is the fulcrum.

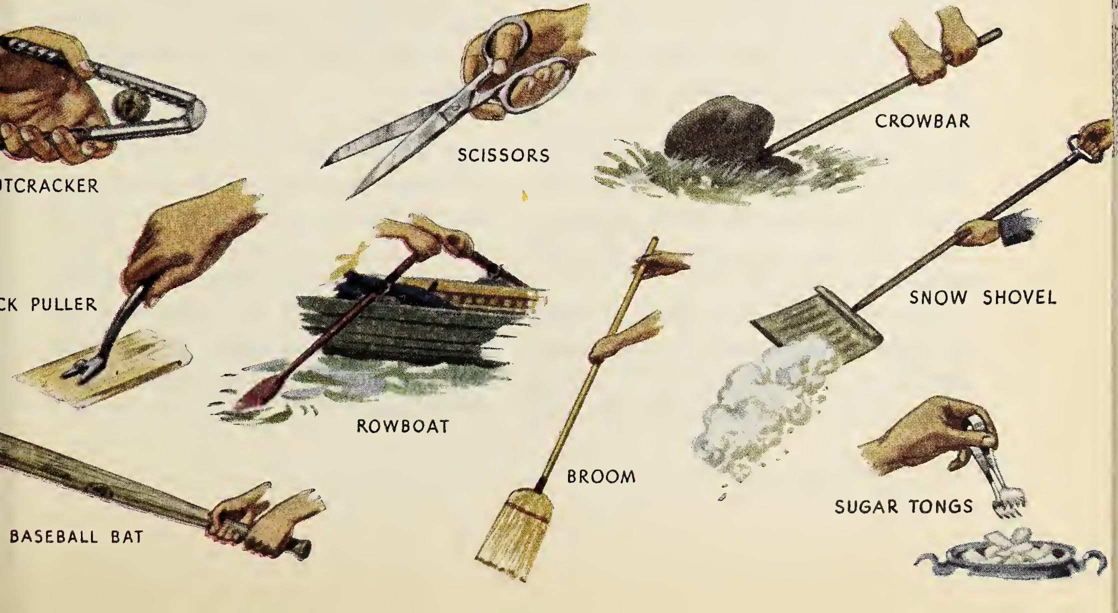
You can use a lever to lift a big, heavy stone. All you need is a strong iron bar and a smaller stone. Put one end of the bar under the big stone. Set the small stone under the bar so that the bar rests on it. The small stone is the fulcrum of the lever. To lift the big stone with the least force, have the small stone as close to it as possible. Why? Now push down on the other end of the lever. Do you see how you can lift the big stone up by pushing down?

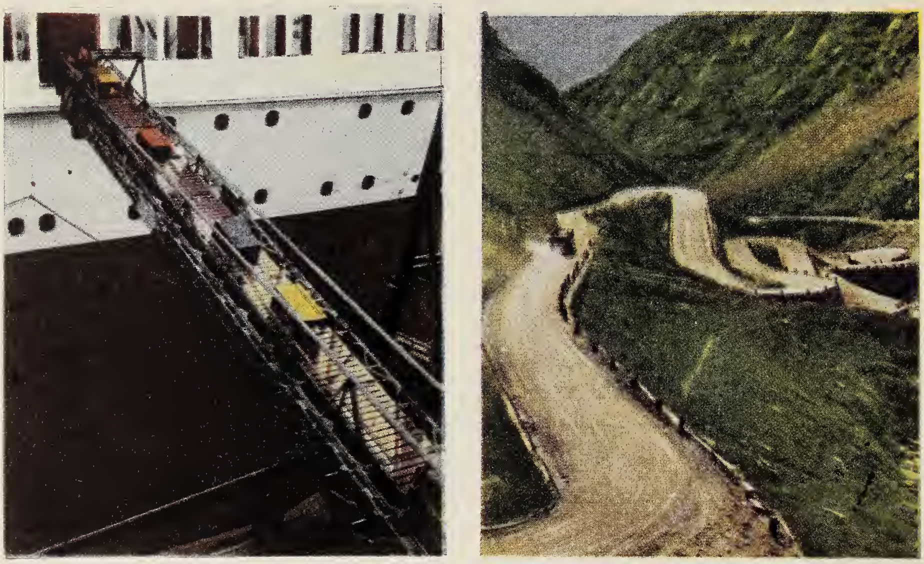
Look at the picture of the nutcracker on this page. How does it break a nut open? Notice where the force is put to crack the nut. You push the ends of the handles together with your hands. Can you find the fulcrum? The fulcrum is the hinge at the other end. This nutcracker is a lever, but it is not the same kind as the one you used before.

The picture of the sugar tongs shows still another kind of lever. The fulcrum is at one end just as in the nutcracker. But to close the tongs, you put the force on the sides instead of putting it on the ends. There are three main kinds of levers, but they are all alike in one way. Every lever has three parts—a fulcrum, a part where the force is put, and a part where the work is done. Look for levers at home, at school, and in other places.

---

1. *Look at the pictures of levers on this page. Then for each lever tell where the fulcrum is, where the force is put, and where the work is done. Why is each lever useful?*
2. *You want to use a lever to lift a weight with the least force. Where should you put the fulcrum?*
3. *Tell how you can use a lever to lift something up by pushing down.*
4. *When you are playing on a seesaw with a child who weighs less than you, which one of you should move nearer the middle of the board to make it balance? If you could move the board, should you sit on the long end or the short end? Why?*





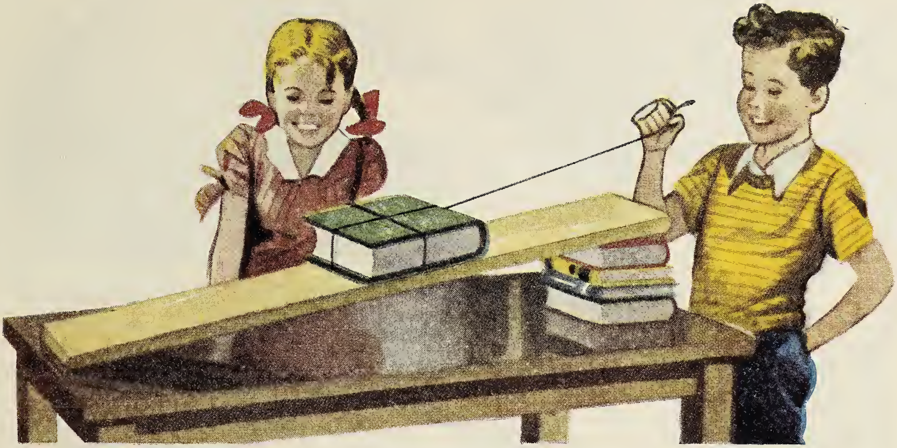
Here are two ways in which inclined planes are used. Watch to see if you can find some other ways.

How do we use inclined planes?

YOU HAVE PROBABLY watched men loading boxes and barrels into a truck. The floor of the truck is several feet above the ground. If the boxes and barrels are not too heavy, the men just pick them up and set them in the truck. But if they are hard to lift, the men use another way to get them up. One or more planks are used to make a slope from the ground up to the floor of the truck. Then the men slide the boxes and roll the barrels up the slope.

The slope made of planks is really a kind of simple machine. Scientists call it an *inclined plane*. Inclined means sloping or slanting. A plane is any flat surface. The floor of your room is a plane. So is the top of a desk or table. An inclined plane is a flat surface that is sloping or slanting. In a theatre, the floor often slants or slopes. So it is really an inclined plane.

You can make an inclined plane and use it to do an experiment. Get a smooth board about four feet long and six inches wide. Near one end of a table, put a stack of books about one foot high. Let one end of the board rest on the stack of books and the other end on the table. Because the board is sloping or slanting, it is now an inclined plane.



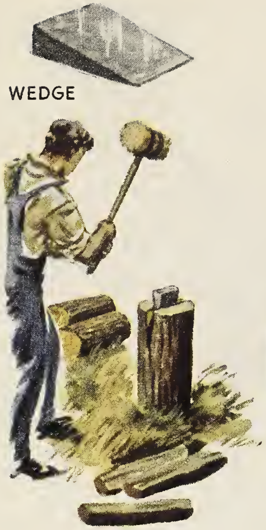
Now let us see how we can use this machine to make our work easier. Tie a strong cord around a big dictionary or any other heavy weight. Take hold of the cord with one hand and lift the dictionary from the table to the top of the stack of books. Was it hard to do?

Set the dictionary on the table again. Slip the hook of a spring balance under the cord. Then lift up on the ring and weigh the dictionary. How many pounds does it weigh? How much force did you use to lift it onto the stack of books? To lift the dictionary, you must pull up with just as many pounds of force as the dictionary weighs.

Put the dictionary at the bottom of the inclined plane. Take hold of the cord with one hand and pull the dictionary up the slope to the top. Was it easier to pull the dictionary up the inclined plane than to lift it straight up?

You can use the spring balance to find out how much force it takes to pull the dictionary up the inclined plane. Put the dictionary at the bottom again. Slip the hook of the spring balance under the cord and take hold of the ring. Now pull slowly and evenly up along the sloping board. As you pull, look at the spring balance and see how many pounds of force it takes to move the dictionary. It takes fewer pounds of force than the dictionary weighs.

If you were rolling a barrel up into a wagon, would you use a long board or a short board for an inclined plane? You can find out which is easier if you do another experiment. This time use a board about twice as long as the one you used before. What did you find out?



WEDGE

KNIFE

AXE

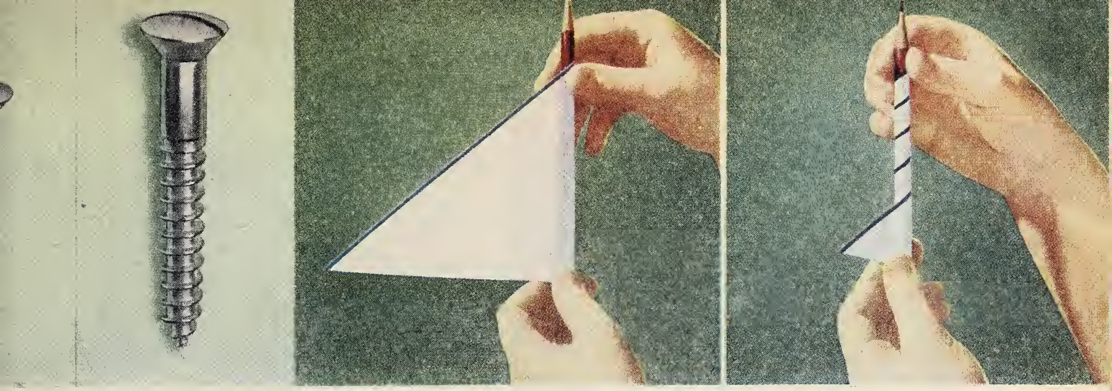
SNOWPLOW

Inclined planes make it easier to lift things. When horses, cows, sheep, or pigs are loaded into railroad cars or trucks, they walk up an inclined plane. A road over a hill or a mountain is an inclined plane, too. You probably use a tool that is an inclined plane every day. Can you guess how you do this?

Every time you use a knife or any other cutting tool, you are using a kind of inclined plane. Look at the picture of the wedge. If you lay a wedge on one of its flat sides, the other flat side makes an inclined plane. How many inclined planes are there in a wedge? Now look at the pictures of the knife, the axe, and the plow. How many inclined planes can you find in each one?

Knives, axes, and plows are kinds of wedges. And a wedge is really two inclined planes joined together. If you drive a wedge into a piece of wood, the thin edge goes in first. As the thicker part follows, the wood splits sideways. When you cut with a knife or chop with an axe, the same thing happens. As a plow is pulled forward, it pushes the soil out to the sides.

You can find many other uses of inclined planes if you keep your eyes open. The sharp teeth of a saw are tiny inclined planes. Look at your own teeth, especially the ones in front that you use to bite off food. Look at the catch on a door. Can you find an inclined plane in the catch that holds a door shut?



Now let us find another use of inclined planes. Look at the picture of screws on this page. A screw is really a kind of inclined plane. Take a square piece of paper and cut a three-sided piece from it. Stand this piece on one of its short sides. Do you see that the long side makes an inclined plane? Now wrap this piece of paper around a pencil, as shown in the picture. The edge of the paper makes a line around the pencil like the edge of a screw.

A screw is an inclined plane that winds around as it climbs. If you had a screw that was big enough, you could start at the bottom and walk up the winding inclined plane to the top. Because screws can pull or push with great force, we use them to hold pieces of wood or metal tightly together. A screw turned by a lever is used to make a machine that can lift very heavy weights with only a small force. This machine is called a jackscrew, or often just a jack.

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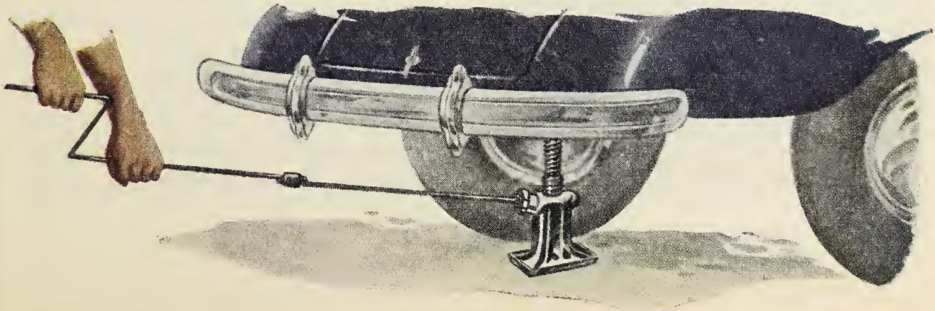
1. *How could you show that it is easier to pull a load up an inclined plane than to lift it straight up?*
2. *Give some examples of inclined planes that you have seen being used. Tell how each one made the work easier.*
3. *Name two kinds of machines that are really inclined planes. How is an inclined plane used to make each one?*
4. *What are the two different kinds of simple machines used in a pair of scissors?*

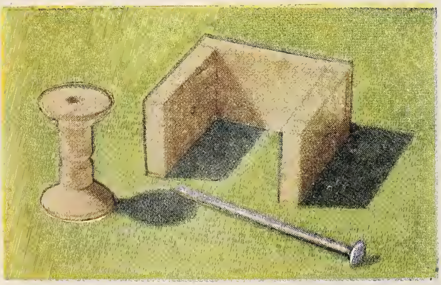


How do we use pulleys?

CAN YOU IMAGINE a world without wheels? You would not have a bicycle, a wagon, or roller skates. There would be no automobiles, streetcars, trains, or airplanes. Windmills, water wheels, steam engines, gasoline engines, and electric motors would not supply energy to help us do our work. To move anything, we would have to lift, drag, or shove with the force of our muscles or the muscles of animals.

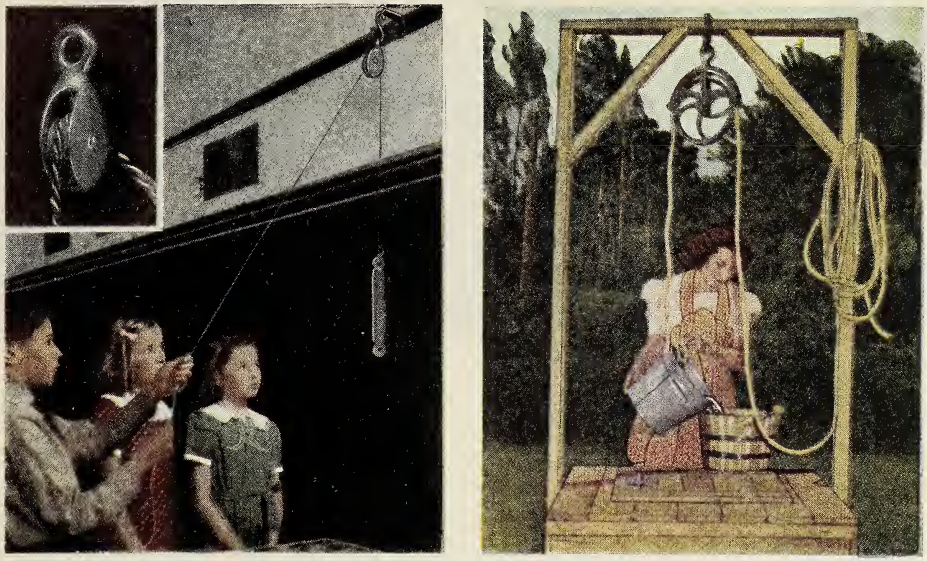
Wheels are among the most useful things ever invented. We use wheels in many different kinds of machines. Yet the Indians did not know how to make a wheel until people from Europe came to America and showed them how. There are savage tribes in Africa and Asia who know how to use levers and inclined planes. But they never use wheels. So, of course, they have no machines that are made with wheels.

One of the kinds of simple machines is called a *pulley*. A pulley is a wheel held so that it can turn easily. A rope or a chain or something like it goes over the wheel. Usually there is a groove in the rim of the wheel to keep the rope or chain from slipping off. Pulleys are made of wood, metal, or some other hard material.



If you haven't a pulley, you can make one. Get a strong spool and a large nail that will slip easily through the hole in the spool. Then get three small pieces of wood. Nail the pieces together, as shown in the picture. Now you are ready to fasten the spool in the frame you have made. Drive the large nail through one of the sidepieces of the frame. Put the pointed end of the nail in the hole of the spool. Then drive the nail through the hole and the other sidepiece. Put a screw eye in the crosspiece of the frame so that you can hang the pulley up.

Now you can do some experiments to see how we use pulleys. Put a hook or nail in the wall up above your head. Hang the pulley up by slipping the screw eye over the hook or nail. Put a strong piece of cord over the pulley wheel. Have the cord long enough so that both ends touch the floor. Tie any small weight to one end of the cord. Then pull down on the other end. As you pull down, the weight goes up. Like the lever you used in another experiment, this pulley changes the direction of the force.



These pictures show you how a fixed pulley is used to lift things.

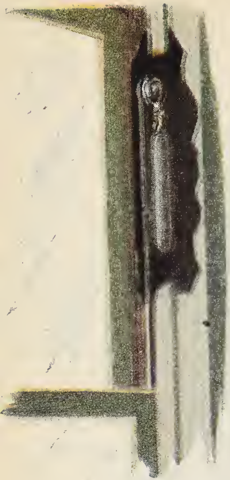
It helps us do work by moving things in one direction while we pull in another direction.

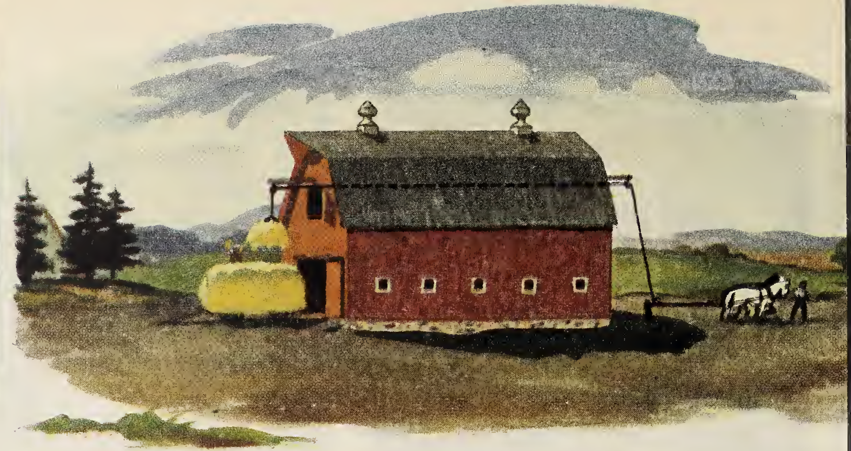
Fill a pail or basket with sand, stones, or anything heavy. Then lift this weight above your head. That was not very easy to do, was it? Use a spring balance to find out how many pounds you lifted. How much force did you use? Now see if you can lift the weight more easily by using a pulley.

Tie one end of the cord to the handle of the pail or basket. Pull down on the other end of the cord until the weight is above your head. Was it easy to lift the weight when you used the pulley? Let the weight down. Tie the ring of the spring balance to the other end of the cord. Take hold of the hook and pull down slowly and evenly. As you pull, look at the spring balance and see how many pounds of force it takes to lift the weight.

When you used the pulley, you found that it was easy to lift the weight above your head. It took as much force as without the pulley, but it was easier to do. You already know that it is easier to push down with a lever than to lift up. It is also easier to pull down with a pulley. The weight of your body helps you pull down or push down.

The pulley used in the experiments is called a *fixed pulley* because it is fastened, or fixed. It stays in one





place, and only the weight and cord move. A fixed pulley does not increase the force. But it does make our work easier by changing the direction of the force. We can use it to lift things higher than our heads by pulling down on a rope.

How does the flag get to the top of your school flagpole? No one climbs the pole. Before the flagpole was set up, a fixed pulley was fastened to the top. Then a long rope was run over the pulley wheel. To raise the flag, all you need to do is fasten it to the rope and then pull down. Up goes the flag to the top of the pole! As you pull in one direction, the flag moves in the other direction. A pulley helps us because we can lift things above our heads by pulling down.

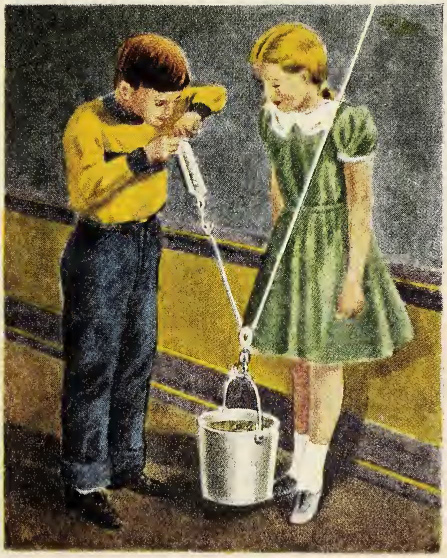
In your schoolroom, you can find another use of fixed pulleys. Go to one of the windows and lift it. The window is probably big and heavy. Why can you raise it so easily? Look up near the top of the window. Do you see pulleys on each side? Each side of the window is fastened to a rope or chain that goes over a fixed pulley. Inside the window casing on each side of the window is a weight fastened to the other end of the rope or chain. You can see the rope and the weight for one side of a window in the picture on this page. The two weights are almost heavy enough to pull the window up by themselves. It takes only a little of your force to raise the window.

The other picture shows one way in which a farmer uses fixed pulleys to lift hay up into his barn. Near the top of one end of the barn is a pulley. On a short post just outside the barn door is another pulley. A rope goes from the horses, over the pulleys, through the barn, and down to the load of hay. When the horses pull on the rope at one end of the barn, the hay goes up to the opening near the top of the other end. The hay then slides along a track into the barn.

As you can see, fixed pulleys are very useful. But we also use pulleys in another way. An experiment will show you how we do this. Tie one end of a strong cord to a hook or nail high up on the wall. Then attach any small weight to the screw eye in the pulley frame. Put the cord through the pulley and then pull up on the other end of the cord. As you pull up, the pulley moves up, carrying the weight up with it. A pulley used in this way is called a *movable pulley* because it moves along the cord.

If you do another experiment, you can discover how a movable pulley helps make our work easier. Fill a pail or basket with sand, stones, or anything heavy. Use a spring balance to find out how much it weighs. How much force does it take to lift the weight? Now fasten the weight to the screw eye in the pulley frame. Tie the hook of the spring balance to the free end of the cord. Take hold of the ring of the spring balance and pull up until you lift the weight.

Look at the spring balance and see how many pounds of force you must use to lift the weight. How much force did it take to lift the weight without the pulley? Did it take more force or less force to lift the weight with the pulley? How does a movable pulley make your work easier? The hook or nail to which the cord is tied holds up half the weight. So you need to lift only the other half. Actually, you must lift a little more than half for a reason you will learn later.

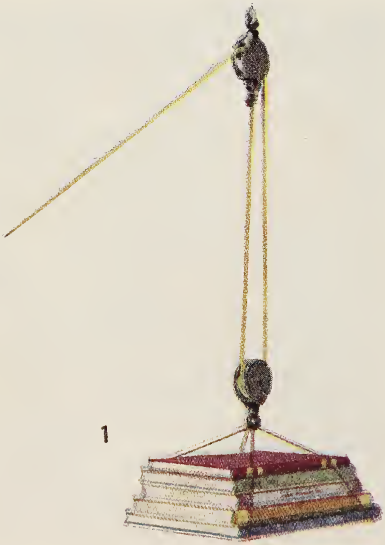


With a movable pulley, you can lift a heavy weight with a much smaller force. If you lift a weight of ten pounds with a fixed pulley, you have to pull with a force of about ten pounds. But if you lift a weight of ten pounds with a movable pulley, you have to use a force of only about five pounds.

Often several pulley wheels are set side by side in one frame of wood or metal. The frame and the pulley wheels are called a *pulley block*. Two pulley blocks and the rope that runs over their wheels are called a *block and tackle*. The pictures on this page show how a block and tackle is used. The more pulley wheels there are in the block, the easier it is to lift a weight.

You can see that this is true if you do an experiment. Use one fixed pulley and one movable pulley to lift a weight, as shown in the first picture. With the spring balance, measure the amount of force you need to lift the weight. Then use a fixed pulley block with two pulley wheels and a movable pulley block with two pulley wheels, as shown in the second picture. With the spring balance, measure the force you need to lift the weight this time. Was it much easier to lift the weight when you used more pulley wheels?

Pulley blocks are used in cranes and derricks to lift heavy loads, such as big pieces of steel. They are also used to raise and lower elevators in tall buildings or lifeboats on ships. Pianos and safes are lifted to the upper stories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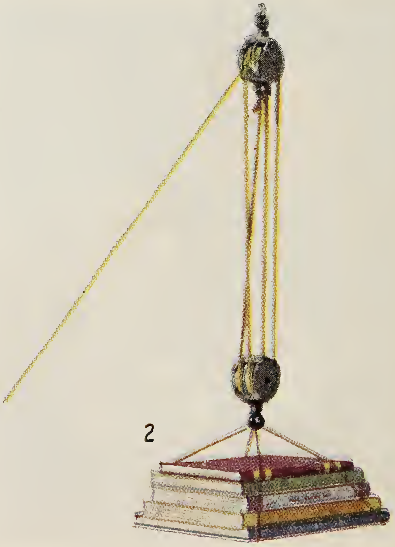
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The painters pull their platform up to the top of the building with pulley blocks.

of buildings with pulley blocks. Look at the pulleys in the picture on this page.

Now let us see what we have learned about pulleys. They make our work easier in two different ways. With a fixed pulley, we can change the direction of a force. By pulling down on a rope, we can lift things up above our heads or to places where it is hard to go. It takes just as much force as it would without the pulley, but we can use the weight of our bodies to help us pull down. With a movable pulley or several pulleys together, we can lift heavy weights with much less force than we could if we did not use the pulleys.

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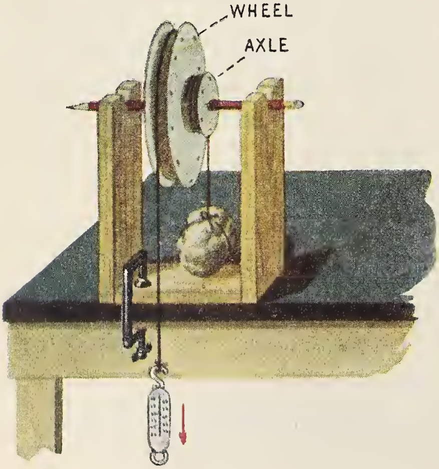
1. *In what two ways do pulleys make our work easier?*
2. *Tell how you could use a pulley to lift fifty pounds with a force of only about twenty-five pounds.*
3. *If a weight is very, very heavy, would you use one pulley or several pulleys to lift it? Why?*
4. *Tell what you have learned about each of these.*
   Fixed pulley   Movable pulley   Pulley block   Block and tackle
5. *Make a list of all the uses of pulleys that you can find.*

How do we use a wheel and axle?

A WHEEL is used in another kind of simple machine. This kind is called a *wheel and axle.* The rod that goes through the centre of a wheel is the axle. The wheel of a pulley turns freely on an axle. But in a wheel-and-axle machine, the wheel is fastened firmly on the axle. When either the wheel or the axle is turned, the other one turns, too.

You can build a wheel-and-axle machine. Get a wide board at least one inch thick. Draw a circle six inches across on the board. Cut out the circle with a saw. Then draw a circle two inches across on the board and cut it out. In the centre of each circle, bore a hole just big enough to force a round pencil through. The large circle will be the wheel, and the small circle will be the axle.



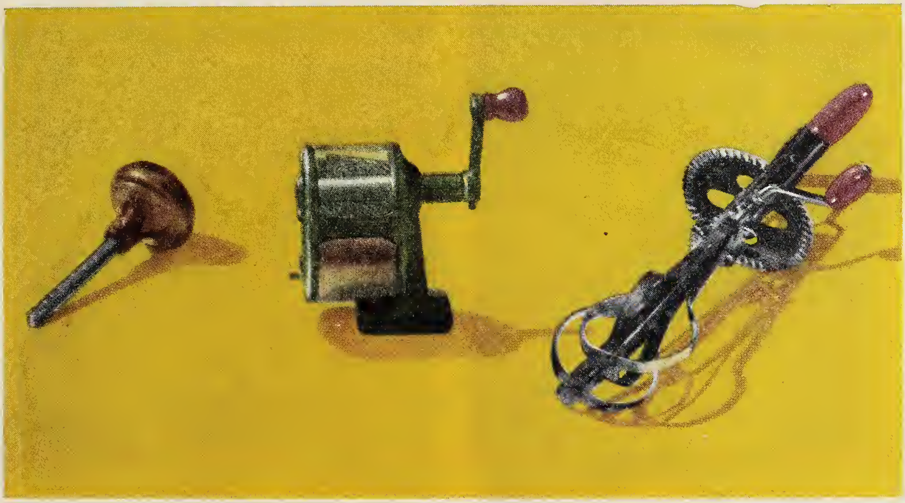
Cut two large circles and one small circle from cardboard. These should be just a little bigger than the wooden circles. Tack the cardboard circles to the wooden circles, as shown in the picture. Punch a hole in the centre of each cardboard circle so that you can put a round pencil through it.

Now put the axle on the wheel so that the holes fit right together. Nail the axle to the wheel. Force the pencil through the holes. If it does not fit tightly, use glue to fasten it. Put a tack in the rim of each wooden circle. Tie a cord to each tack.

Make a frame from three pieces of wood, as shown in the picture. Nail the pieces together. Cut a notch in the top of each upright piece. Set the pencil in the notches. Clamp or hold the frame on the edge of a table.

Get a stone or any weight and weigh it. Wind the cord around the axle several times. Tie the weight to the end of this cord. Now wind the other cord around the wheel several times. Attach a spring balance to this cord. Pull down on the spring balance until the wheel turns and lifts the weight. How much does the weight weigh? How much force lifts it? What does this show?

You can find a wheel-and-axle machine in your schoolroom. Do you know what it is? It is a doorknob! Perhaps you never thought of the

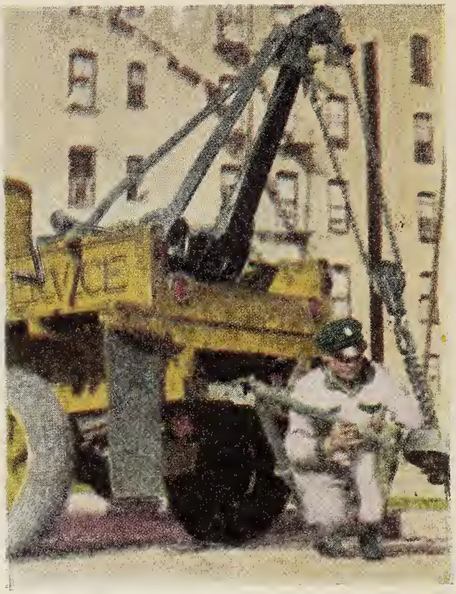


knob as a wheel. It has no spokes as some wheels have, but it is a wheel just the same. The knob is fastened firmly to a rod that runs through its centre. This rod is the axle. When the knob is turned, the rod also turns and moves a catch inside the door.

Let us see how this wheel-and-axle machine makes our work easier. Use a screwdriver to loosen the little screw that holds the knob on the rod. Take the screw out and remove the knob. Now try to turn the rod with your fingers. Can you make the catch move? Then put the knob back on the rod. Turn the knob with your hand. Is it easier to make the catch move now?

A wheel and axle helps us do our work. We can use it to increase a force. A little force on the knob produces a larger force on the rod. A wheel and axle acts in the same way as the lever you used in an experiment. You remember that a small force on the long end of the lever moved a heavy weight on the short end. The steering wheel of an automobile or bus is a wheel and axle. You know that you could not steer an automobile just by turning the rod to which the wheel is fastened.

If you look around your schoolroom again, you can probably find another wheel-and-axle machine. Is the pencil sharpener turned by a crank? The crank is really a spoke on a wheel. Instead of turning the whole wheel, you just turn one spoke. The crank turns the axle, and the axle moves the blades inside the



pencil sharpener. The crank of an egg beater, a meat grinder, or a clothes wringer is really a spoke on a wheel, too.

Without the crank, you would have a hard time making a pencil sharpener, an egg beater, or a clothes wringer turn. When a big wheel or a long spoke is fastened to a small axle, a little force on the wheel or the spoke will move a heavy weight attached to the axle. That is one reason why we use a wheel and axle in so many ways.

The picture on the right at the top of this page shows another wheel-and-axle machine. You may have seen a machine like this on the back of an automobile repair truck. Can you find the part that is the wheel and the part that is the axle? How does the machine help lift a heavy automobile?

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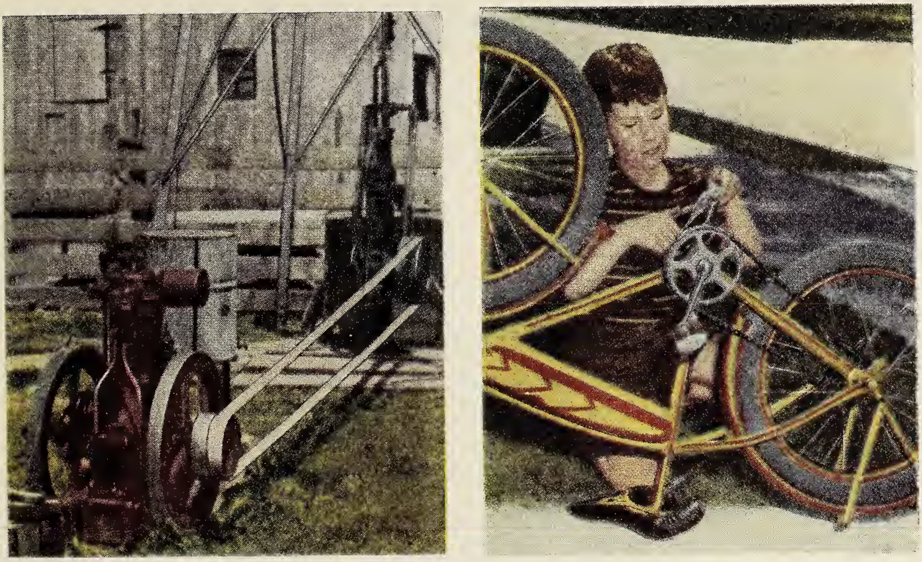
1. *A pulley has both a wheel and an axle. Why is it not called a wheel-and-axle machine?*
2. *When you use a wheel-and-axle machine to increase your force, should you use your force on the wheel or the axle?*
3. *Why is a doorknob a wheel-and-axle machine?*
4. *Why is a large wheel used on the steering rod of an automobile?*



Can you find other machines in which a belt makes one wheel turn another?

How can one wheel turn another wheel?

WHILE PEOPLE were learning how to use wheel-and-axle machines, they discovered that they could also make one wheel turn another wheel. One way to do this is to put a tight band around the wheels. This band is called a *belt*. When one wheel is turned, the belt moves with it and turns the other wheel.

The chain on a bicycle is really a belt. Look at a bicycle and see how you make it go. You push down on pedals with your feet. The pedals are attached to the cranks that are fastened to an axle. The axle turns a big wheel, and this wheel moves a chain. The chain makes a little wheel turn, and this little wheel makes the rear wheel of the bicycle go around.

Notice that the wheels connected by the chain have notches and points on them. Crosspieces in the chain fit into the notches, and the points fit into open places in the chain. A wheel with notches and points on it is called a *gearwheel*, or just a *gear*. The points on a gearwheel are called *teeth*. The teeth and notches on a gearwheel help prevent slipping.

As people worked with wheel-and-axle machines, they found that they did not have to use a belt or chain to make one wheel turn another. They just put the rim of one wheel against the rim of another wheel. When one wheel is turned, it rubs against the other wheel and makes that one turn, too. But even when the wheels are pushed tightly together, they still slip a little. Do you know how we keep them from slipping? We use gearwheels instead of wheels with smooth rims. The teeth of one gearwheel fit into the notches of the other.

Look at the gearwheels in an egg beater. Notice how the teeth of the big wheel fit between the teeth of the smaller wheels. Turn the handle so that the big wheel goes around once. How many times do the little wheels go around? Do you see how we can use gearwheels to change speed? A big gearwheel turning slowly can make a little one turn much faster.

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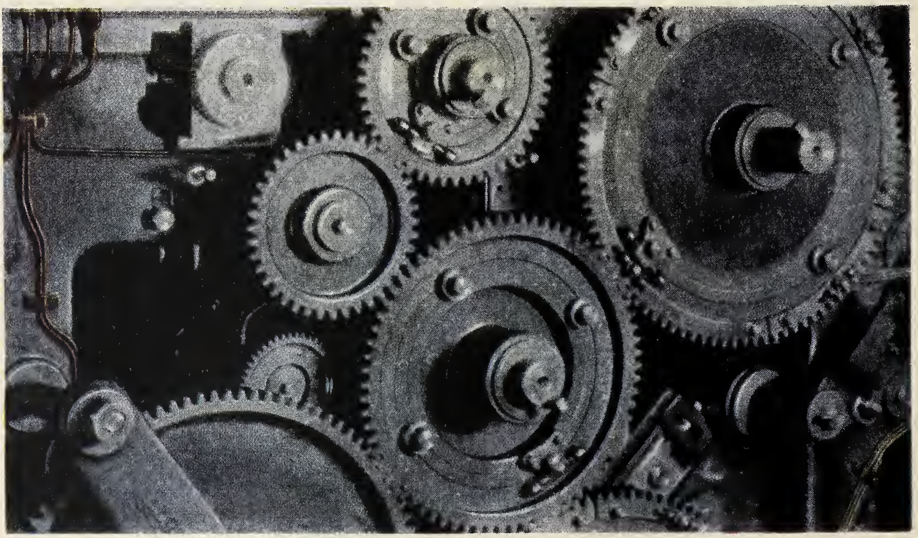
1. *When a large wheel turns a small wheel, does the small wheel go more quickly or more slowly than the large wheel? Give an example.*
2. *When a small wheel turns a large wheel, which wheel goes more quickly? Give an example.*
3. *What are two ways of making one wheel turn another wheel?*
4. *Tell how a special kind of wheel prevents slipping.*
5. *Use a bicycle to find out how many times the rear wheel goes around when the pedals go around once. Explain the reason.*

Look at this picture carefully to see how one gearwheel turns another.



How can we make machines work better?

You know that it takes energy to produce a force that will make things move. Energy from food gives force to our muscles and the muscles of animals. The forces of moving air, moving water, and electric current come from the energy they have. Steam engines and gasoline engines get their forces from the energy stored in fuels.

Machines make our work easier because they help us make better use of the forces we have. We use machines to increase force, to change the direction of force, and also to change speed. But in every machine something moves. And when it moves, it rubs against something else. Moving parts rub against each other, or a moving part rubs against a part that stands still. When any two things rub against each other, we say that there is *friction* between them. Friction means rubbing.

In every machine you have used, there is always some friction. A lever rubs on its fulcrum. Things rub against the surfaces of inclined planes. A pulley wheel rubs on its axle, and a rope rubs on the pulley wheel. Wheels rub against belts, chains, and other wheels.

Some of the force that is used in a machine is always wasted. It is used to overcome the friction. To make up for this loss of force, we have to use more energy. So friction in machines wastes some of the energy that we use to do our work.

When you use a fixed pulley to lift a weight of ten pounds, you have to pull down with a little more than ten pounds of force. If you use one movable pulley to lift the same weight, you have to pull up with a little more than five pounds of force. With each pulley, you have to use a little more force than you would use if there were no friction. The extra force is used to overcome friction.

To make our machines work better, we try to keep friction as small as we can. There are several ways to do this, and we use them all. You can see one way that we use if you do a very easy experiment. Move a rough board over a rough board. Then move a smooth board over a smooth one. Did you have to use more force with the rough boards than with the smooth ones?

When rough surfaces rub on each other, there is much friction. But when smooth surfaces rub on each other, there is less friction. Wax on a floor or ice on a sidewalk makes such a smooth surface that you can slide easily. To make the parts of machines slide over each other easily, we make their surfaces as smooth as we can. If you look at some machines, you will see that the parts are very smooth.

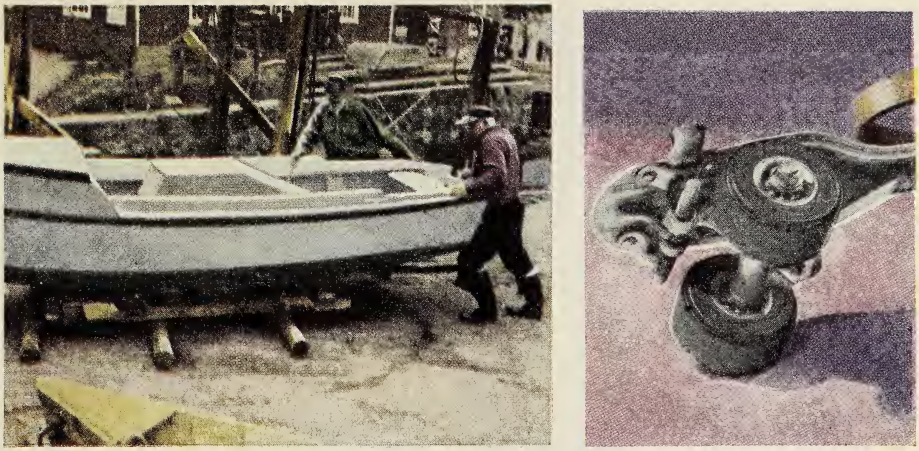
Another way to cut down friction in machines is to put oil or grease between surfaces that must slide over each other. The oil or grease makes a very smooth, thin layer between the surfaces and keeps them from rubbing against each other. Of course, there is some friction between the oil or grease and the surfaces. But it is much less than the friction between the surfaces would be.

You can see that this is true if you do an experiment. Rub two flat pieces of metal back and forth against each other. Now put some oil or grease between them and rub them back and forth again. Can you feel how much more easily they slide over each other now? This is one reason for oiling and greasing machines.

Here is another reason for using oil and grease. You know that when things keep rubbing on each other long enough, they finally wear out. And the rougher they are, the faster they wear. Friction between the soles of your shoes and floors and sidewalks makes your shoes wear out. Friction not only makes our machines waste energy, but it also makes them wear out. They will last much longer if we keep a layer of oil or grease between the surfaces that must slide over each other.

Oil and grease do another important thing, too. Rub the palms of your hands over each other as fast as you can. Do they soon feel hot? Try rubbing a penny back and forth on your sleeve as fast as you can. It will get so hot that you will find it uncomfortable to hold. If parts of a machine rub on each other, they get very hot. But when oil or grease is put between them, they slide over each other more easily. There is less friction, and they do not get so hot.

Friction in our machines wastes energy by changing it to heat we do not want. The waste of energy is bad enough, but the heat may be even worse. Did you ever hear anyone say he had "burned out" his automobile? Something kept the oil from getting between the moving parts of the engine. These parts will bend, break,



Two men can move this boat by using rollers. Look closely at the roller-skate wheel, and you will see the tiny ball bearings around the centre of the wheel.

or even melt if they get hot enough. When there is no oil to keep them from rubbing against each other, they soon become too hot. Then the engine is ruined.

If you want your bicycle and roller skates to work well, be sure to keep them oiled. Put oil or grease on the parts that must slide over each other. Probably your mother keeps an oil can in your home. She puts oil on the moving parts of her sewing machine, vacuum cleaner, washing machine, and other household machines.

There is still another way that we use to cut down friction in our machines. We use wheels or something like them. It is easier to roll things over a surface than to slide them. An experiment will show you that this is true.

Fill a small box with sand, stones, or anything heavy. Slide it along the top of a table by pulling or pushing. Now set the box on a toy wagon. Move the wagon by pulling or pushing it. Is the box easier to move when you use wheels? Get about a dozen round pencils and lay them on the table a few inches apart. Set the box on the pencils and roll it over them. Do you see that the pencils act in the same way as the rollers men use to move heavy weights? If you can, get some little round metal balls or shot. Put them on the table and move the box over them. Is it easy to do?

We use wheels, rollers, and balls in our machines to cut down friction. They make the parts roll over each other instead of sliding over each other. Rollers and balls are used to

make *bearings*. A bearing is any part of a machine on which another part turns or slides. We call it a bearing because the other part bears down on it, or presses against it. As you might expect, much of the friction in a machine takes place at the bearings.

You can find one kind of bearing in a pair of roller skates or the rear wheel of a bicycle. This kind is made of balls. So it is called a *ball bearing*. If you look carefully around the wheels, you can see the balls. Another kind of bearing is made of rollers. It is called a *roller bearing*. We use roller bearings in the wheels of railroad cars and in other big machines. Bearings are made as smooth as possible. Then oil or grease is put on them to keep them from rubbing against each other or on other parts.

Most of the time we are trying to cut down friction in our machines. But sometimes we need to use friction, too. Some machines or some of the parts of machines would not work without friction. If there were no friction, belts would not turn wheels. The belts would just slip around on the wheels, and the wheels would not be turned. Friction also keeps things from slipping on inclined planes. In winter when there is much ice and snow, an automobile often cannot drive up a hill until sand or ashes are put on the road. The sand or ashes make the surface of the road rough. Then there is friction between the automobile tires and the road.

Did you ever see a toy express wagon with a brake on it? The brake is a handle on the side of the wagon over one of the back wheels. When you want to stop or slow down, you press this handle against the wheel. Friction between the end of this handle and the wheel makes the wheel stop moving. The brakes of automobiles and trucks work because of friction. The brakes have a rough material on them that causes much friction when they press against a part of the wheel.

We need friction between the tires and the road, too. The tires are made so that their surfaces are not smooth. This makes friction between the tires and the road. When the tires are old and worn, they become smooth. Then there is less friction. The automobile slides easily and does not stop quickly when the brakes are put on.

If you play baseball, you know that you cannot bat the ball very far if the bat slips around in your hands. If the handle of the bat is slippery, you can put some tape around the handle to make it easier to hold tightly. You are making more friction between the bat and your hands.

Think of other machines you have read about or used. Can you think of some that work better because of friction?

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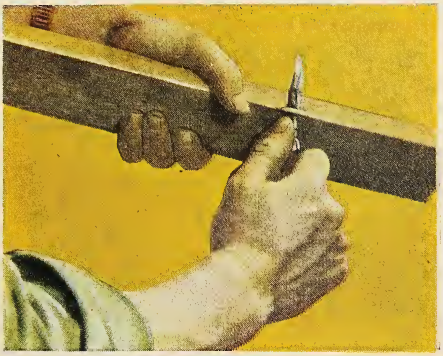
1. *Give three reasons why we try to cut down friction in our machines.*
2. *What different ways do we use to make our machines run better? Tell how each way helps.*
3. *Why do pianos and other heavy pieces of furniture often have small wheels called casters under them?*
4. *The axles of the wheels of railroad cars sometimes get very hot. What do you think causes this?*

How can we use machines safely?

THE OTHER DAY, a little girl got her hand caught in the wringer of her mother's washing machine. Her hand and wrist were badly hurt. Machines help us. But they are dangerous, too, unless we use them carefully. Every year, thousands of people are hurt by machines. Sometimes it is not the fault of the people. Many times, it is entirely their fault. They are just careless or in too much of a hurry.

Knives, saws, hammers, and axes are helpful machines that we often use. They can be dangerous, as you know. Axes and knives have very sharp edges. If an axe or a knife slips or suddenly breaks through the wood, you may get a bad cut. If you are cutting with a knife, cut away from yourself—not toward yourself.



In factories, belts and gears should all be covered so that the people who work near them will not be injured by them.

If you are hammering, give the nail a few light blows while you are holding it to get it started. Then move your hand away while you drive the nail in with heavy blows. The jagged teeth of a saw make a bad wound. You may have to hold your hand close to the saw to guide it when you start sawing. Be very careful when you do this.

Many times, fingers and hands have been badly cut or bruised by getting caught between a rope and a pulley. You can burn the skin on your hands if you hold too tightly to a rope that is sliding through pulleys rapidly.

Wheels with swiftly running belts have hurt and killed thousands of people. A piece of a person's clothing sometimes gets caught in the belt, and the person is thrown against a ceiling or wall with great force. It is important to be very careful if you are near wheels and belts. Stay safely away from them when they are running.

Gearwheels are very dangerous. Once you get your hand or arm caught between two moving gearwheels, you cannot get it out. Gearwheels are so dangerous that in many places the owners of factories are required by law to have all gears covered. If you live on a farm, you will need to be on your guard against many dangerous gearwheels.

Sometimes on playgrounds boys and girls are careless and are injured by levers. A boy or girl may think it is funny to jump off the end of a seesaw when the child on the other end is high up in the air. When the high end comes down with a bang, a leg may be caught under it and severely hurt or even broken. Levers may be dangerous in other ways. If you are pushing down hard on a lever, the weight you are trying to lift may suddenly move up. Down you go. Your fingers may be bruised or broken. You may even get a bad bump on your head. The same things may happen if the lever breaks when you are pulling on it.

There are hundreds of ways in which machines can injure you. You must learn to be careful with machines. One important thing for you to remember when you are using machines is this. *Never hurry. When you hurry, you are likely to become careless.*

Safety rules for using machines

1. Have a place for each machine and put it back in its place when you are through using it.
2. Never leave tools on a stairway.
3. Have a place for brooms and mops where they cannot fall across a passageway.
4. Set heavy tools where they cannot fall on someone.
5. Put knives and other sharp tools away with the sharp edges pointing away from the person who will next pick them up.
6. Do not run with a pointed tool, such as a knife or a pair of scissors.
7. Always cut away from yourself when using a sharp tool.
8. Lay garden tools on the ground so that the sharp parts are pointing downward.
9. Be very careful when you use machines with wheels, belts, and gears, such as electric fans, sewing machines, washing machines, and clothes wringers.
10. Keep your fingers away from wheels and gears when they are moving.

1. *Tell some dangerous things you have seen people doing with machines.*
2. *Make a list of "danger spots" around machines in your home.*
3. *There should not be any "danger spots" around machines in your school. Find out whether there are such spots.*

QUESTIONS TO ANSWER

1. In the pictures on these two pages, people are using machines to help with their work. What kinds of machines are they using? How are these machines making the work easier?

2. What kinds of simple machines could you make from a board and a block of wood? What kinds could you make from a wheel and a rod?

3. How are fixed pulleys different from movable pulleys?

4. Which kind of simple machine is used to—split wood, pull nails, roll a heavy barrel onto a truck, make windows open and close easily?

5. How many different kinds of machines can you find in your school? Tell what each kind is used for.

6. What part of a wheel and axle needs to be greased or oiled? Why?

7. Tell one important thing you have learned about each of these—friction, simple machines, fulcrum, belts, gearwheels, ball bearings.

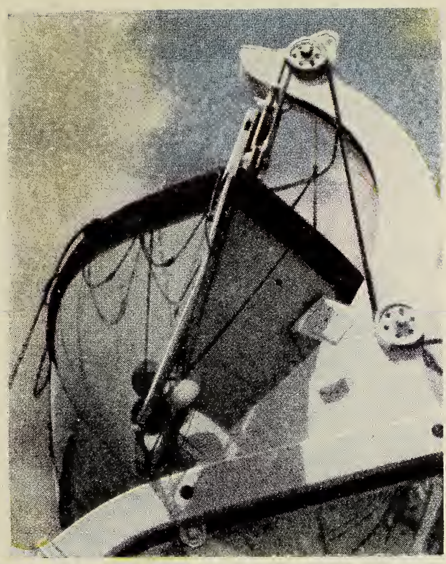
8. Sometimes we want to increase friction. Give some examples that show this.

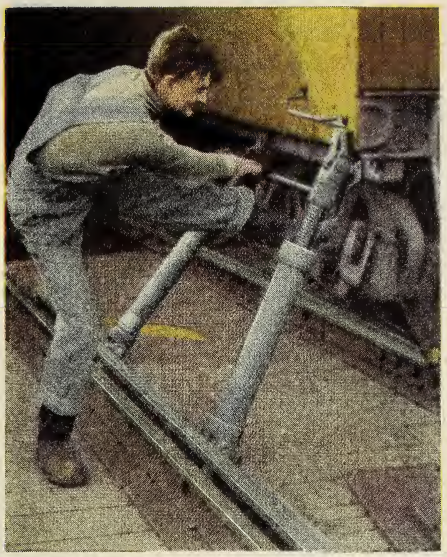
9. In what ways do you think the world would be different if we had no machines?

THINGS TO DO

1. Look at some of the machines in your home and try to find out how they work.

2. Make a list of the machines you have seen being used while you were studying this unit.



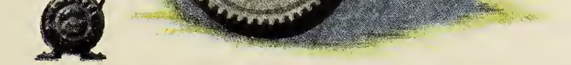


3. Find pictures that show how machines are used to do different kinds of work.

4. Ask someone in your class to bring his mechanical building set to school. Make some machines and find out how they work. Show what kinds of simple machines you use.

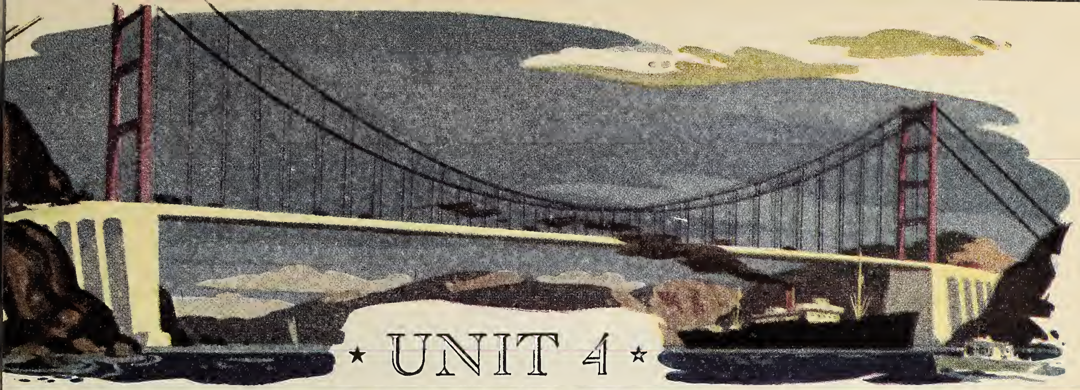
5. Make a collection of all the kinds of tools you can find that are simple machines. Show what kinds of simple machines they are and how they help you do work.

6. Bring some of your toys to school. See how many simple machines you can find in each toy.



★ *In Unit Four You Will Learn* ★

★ *How heating and cooling change the size of solids* ★
★ *What happens when liquids are heated or cooled* ★ *How hot water heats a house* ★
★ *How heating and cooling change gases* ★ *How hot air heats a house* ★
★ *How solids are changed to liquids* ★ *How liquids are changed to gases* ★
★ *How water vapor is changed to liquid water* ★



UNIT 4

How Do Heating and Cooling Change Materials?

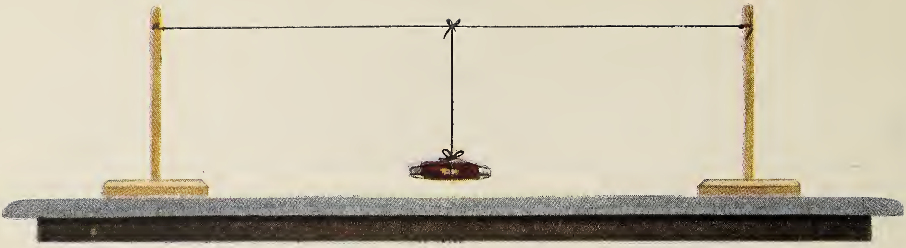
Jack's mother was getting supper. When she had almost finished, she asked Jack to get a jar of fruit from the basement. Then she asked him to open it. It was a glass jar with a metal top that screwed on. But Jack could not unscrew the top, no matter how hard he tried. When his mother saw the trouble he was having, she said, "Pour a little water into a pan and put the pan on the stove. Use just enough water to cover the metal top. Stand the jar upside down in the water until the water is hot. Then try to unscrew the top."

Jack did as his mother said. To his surprise, he was able to unscrew the top very easily. "Why did hot water make it easy to get the top off?" asked Jack.

How do heating and cooling change the size of solids?

Do you know why the top of the jar came off so easily when it was heated by hot water? Suppose you try an experiment to find out. Stretch a piece of copper or iron wire about three feet long between two supports on a table. Stretch the wire as tightly as you can. Hang a small stone or weight from the centre of the wire so that the weight almost touches the table. The picture on page 104 will help you be sure that your experiment is set up correctly. Heat the wire along its entire length. The experiment will not work unless the whole wire is well heated. What happened to the weight? What did heat do to the wire? Leave the weight on the wire because you will need to look at it again.

In the pictures on page 105, the girl is doing another experiment. This one shows what heat does to a solid metal ball. In one hand, the girl is holding a



rod with an iron ring in the end of it. In the other, she has a rod with an iron ball on the end of it. The ball will just go through the ring. In the middle picture, she is heating the ball. Does it go through the ring after it has been heated? When the ball gets very hot, it will not go through the ring. What do you think has happened to the ball?

Suppose that you had a bolt and a nut that just fits the bolt. And suppose you took the nut off the bolt and then heated the bolt in a very hot flame. Do you think the nut would still fit the bolt? It would not, because heat does something to the bolt. Heat would make the bolt so large that the nut would no longer fit on it.

Do you think you know now why the hot top of the jar unscrewed so easily? You may want to try another experiment to be sure you are right. Get a strip of metal and nail both ends down flat on a board. Then heat the metal strip and watch to see what happens. How do you know that the heat is making the metal strip longer?

You saw that the wire became longer when you heated it. It became bigger around, too, although you could not see that. The bolt and the ball will also get bigger if they are heated. We say that these things *expand* when they are heated. This is another way of saying that they get larger, or take up more room.

If you tried many different kinds of solids, you would find that almost all of them expand when they are heated. Now do you see why Jack could unscrew the hot top of the jar? The hot water made the metal top hot. The heat expanded the top faster than it did the glass of the jar. The top got larger. So it was not so tight on the jar. Then the top could be unscrewed easily.

When most solids are heated, they expand. What do you suppose happens when they are cooled? To answer this question, look at the wire you heated after it has become cool again. Does the weight still touch the table? Or is it in the same position it was before you heated it? The wire gets shorter when it is cooled. We say that the wire *contracts*. Contract means get smaller. When the heated bolt cools off, the nut will fit it again. Almost all solids contract, or get smaller, when they are cooled.

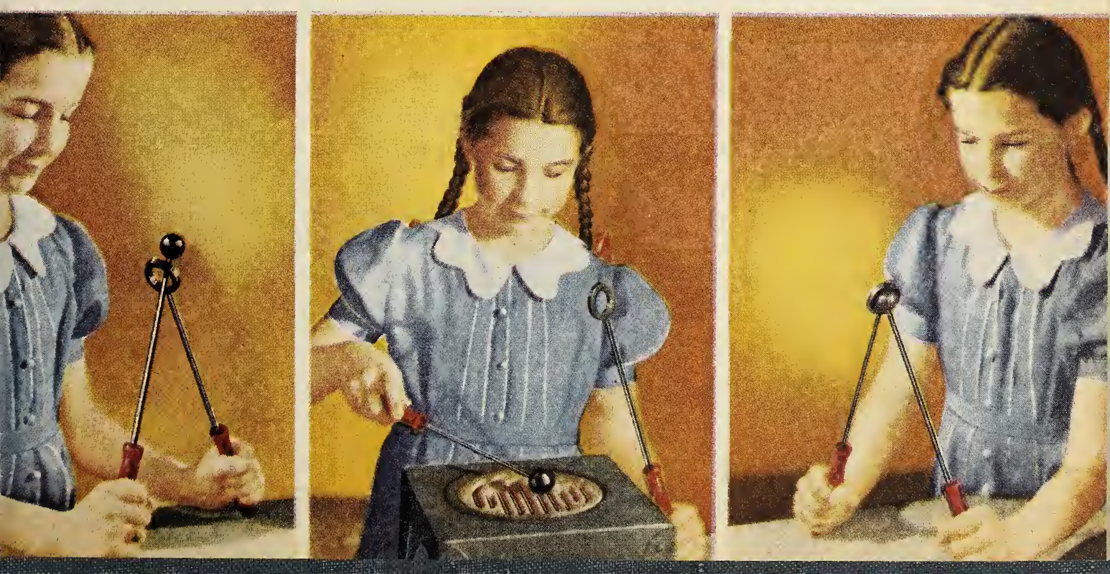
On a very hot summer day, Jack and his father were waiting to cross a long metal bridge. The bridge had opened to let a boat go past. While they were waiting, Jack's father said, "This bridge is several inches longer now than it was last winter when we crossed it."

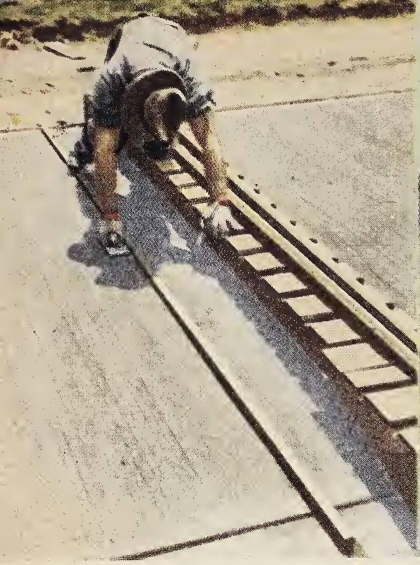
A little later, as they were driving along a country road, Jack's father said, "See those telephone wires sag. They are longer now than they were last winter." Did Jack's father really mean what he said? Or was he joking?

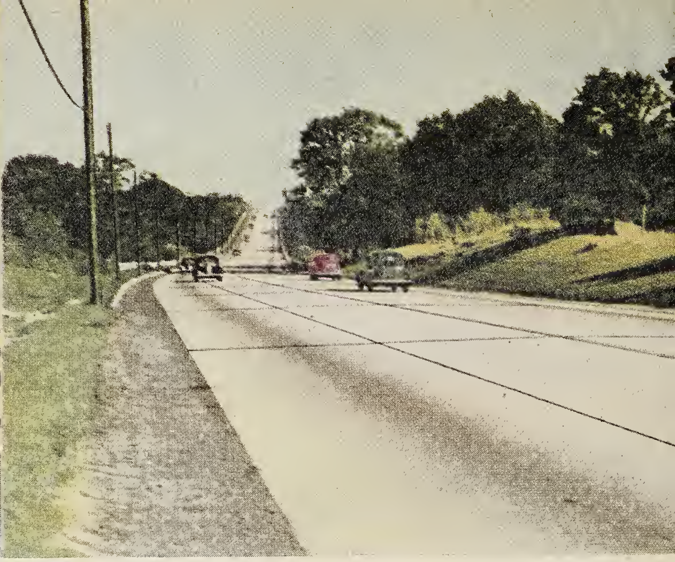
Men who build metal bridges know that the bridges will get longer when the hot summer days come. They build the bridges so that there will be room for them to expand. Sometimes one end of a bridge rests on rollers. When heat expands the metal in the bridge, the end of the bridge can move. Metal bridges are not always placed on rollers, but there is always room left for them to expand when they are heated by the sun. What do you think would happen if the bridge builders did not leave room for the bridges to expand?

Perhaps some of you live where there are huge bridges like the one on page 103. Bridges like this are held up by long, thick ropes, or cables, made of wire. On hot days, the cables are longer than they are on cold days. So the bridge goes up and down a little as the weather changes. But it moves so slowly that you cannot feel it.

Have you ever ridden along a concrete road in summer and felt your car go bump, bump, bump? Do you know why you felt those bumps? Concrete roads are not made in one long strip that goes on for miles. Instead, they are usually made in short







blocks. Between these blocks the road builders leave a small space.

The picture on the left at the top of this page shows how a space is made between the strips. A piece of board is put down into the roadway before the concrete is poured. When the concrete is poured, it comes only up to the board on each side. The concrete hardens. Then the board is taken out, and there is a space between the two strips of road. Often this space between blocks is filled with tar.

Of course, you know that heat makes the tar expand. It also makes the concrete expand and squeeze the tar. So the tar bulges up through the space. When the wheels of the car travel along the road over these bulges of tar, you feel the bumps. You can see the black lines of tar in the picture on the right.

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1. *Why is it important for people to know that heating and cooling change the size of solids?*
2. *What does* contract *mean? What does* expand *mean?*
3. *Windows that open onto fire escapes usually are made with metal frames. Will the windows fit as tightly in winter as in summer? Explain your answer.*
4. *Suppose some workers were stringing telephone wires between poles on a very hot day. Should they stretch the wires tightly? Or should they let the wires sag? Explain your answer.*
5. *What might happen to a concrete road if the builders did not leave a space between the blocks of concrete? Why?*

What happens to liquids when they are heated or cooled?

WHEN JOHN was studying science, he was always thinking of experiments to do at home. One time he decided to find the answer to this question. How hot does water get when it boils? He found a thermometer that his mother said he could have, and he put a pan of water on the stove. While the water was still cool, he set the thermometer in it. As the water slowly heated, the red liquid in the thermometer went up and up. At last, it reached the top of the thermometer. Suddenly the glass broke, and the red liquid ran out into the water.

What made the thermometer burst? Here is an experiment that will help you to find out. You will need a test tube and a rubber or cork stopper with a hole in it. Use a stopper that just fits into the test tube. Get a piece of glass tubing about a foot long that will fit into the hole in the stopper, as shown in the picture.

Fill the test tube with water. Use red ink to color the water so that you can see it easily. Fit the glass tubing into the stopper and then put the stopper into the test tube. Push the stopper down tightly so that some of the water rises in the tubing. Mark the level of the water by tying a string around the tubing. Now heat the water slowly and watch to see what happens. Mark the level of the

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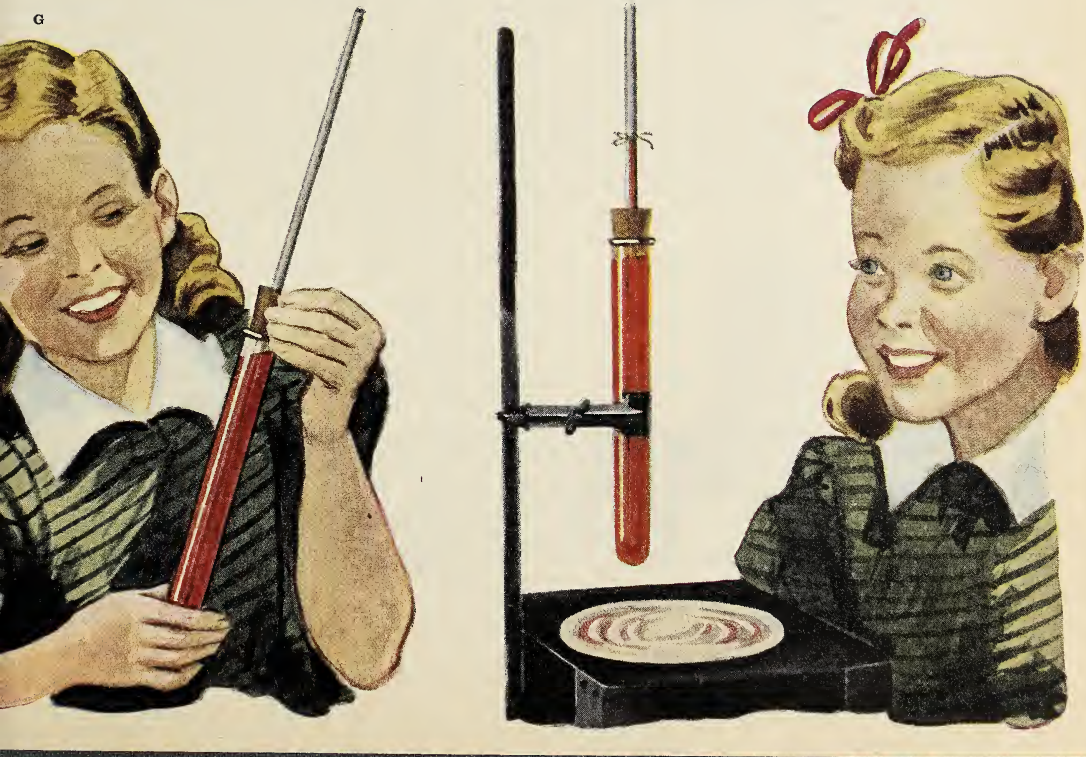

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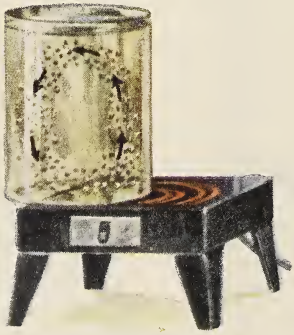
water after it is heated. Is this mark above or below the mark that showed where the water was when it was cool? Did the water expand or contract when it was heated?

You see that when the water is heated, it expands just as most solids do. As the water expands in the test tube, it goes up into the glass tubing. Now cool the test tube and watch the water. Why does it go down in the glass tubing? When the water is cooled, it contracts. Most liquids expand when they are heated and contract when they are cooled.

You know now why John's thermometer broke. The liquid in the thermometer got very hot. It expanded until it took up all the room in the glass. Then it kept expanding until it pushed so hard that it broke the glass and ran out. Some thermometers are made so that they will not break in boiling water. The thermometer is long enough so that there is plenty of room for the liquid to expand. But John did not have that kind of thermometer.



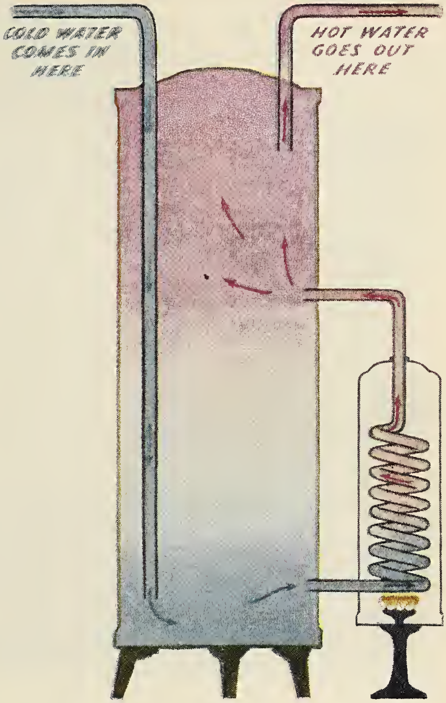
Hold your finger on the bulb of the thermometer in your schoolroom for a minute or two. Why does the liquid rise in the tube?

If you fill a teakettle to the top with cold water and then heat the water, what will happen? Why does this happen? Can you use what you have learned to explain what happened when Jack's mother canned some tomato juice? She boiled the juice and filled glass jars full of the hot juice. Then she sealed the jars and put them away in the cool basement. She opened one of the jars a few weeks later and found that it was no longer full to the top. Do you know why?

You have learned that heat makes most liquids expand. When liquids expand, something else happens to them. Here is an experiment that will help you to understand what it is.

Fill a large glass jar with water and put a teaspoonful of coarse sawdust in the water. The sawdust will soon get soaked with water and sink to the bottom. Now heat only one side of the bottom of the jar and watch the sawdust. Why does the sawdust move up from the bottom of the jar on one side and then down on the other side and then up again?

Water carries the sawdust. The water at one side of the bottom of the jar is getting hot. You know that it is expanding. It is also getting lighter.



It gets lighter in weight because it expands. You know that a teakettle brimful of cold water will run over when it gets hot. The water in the teakettle weighs less when it is hot than when it was cold. A gallon of cold water actually weighs more than a gallon of hot water.

In the experiment, the water on the side of the glass jar that is not heated is cooler than the water on the heated side. It is also heavier than the warmer water. Gravity pulls down harder on the heavier, cooler water. It sinks to the bottom along one side and pushes the lighter, warm water up. This makes a current in the water. Look at the arrows in the picture on page 108 and trace the current. The arrows show that the heavier, cold water is sinking and pushing the lighter, warm water up.

Look at the hot-water heater in the picture on this page. You will see that it works much as the experiment with the sawdust did. As the water is heated in the small tank, the cold water that comes in at the bottom pushes the warm water up and into the top of the big tank. Follow the red and blue arrows, and you will see how the current moves.

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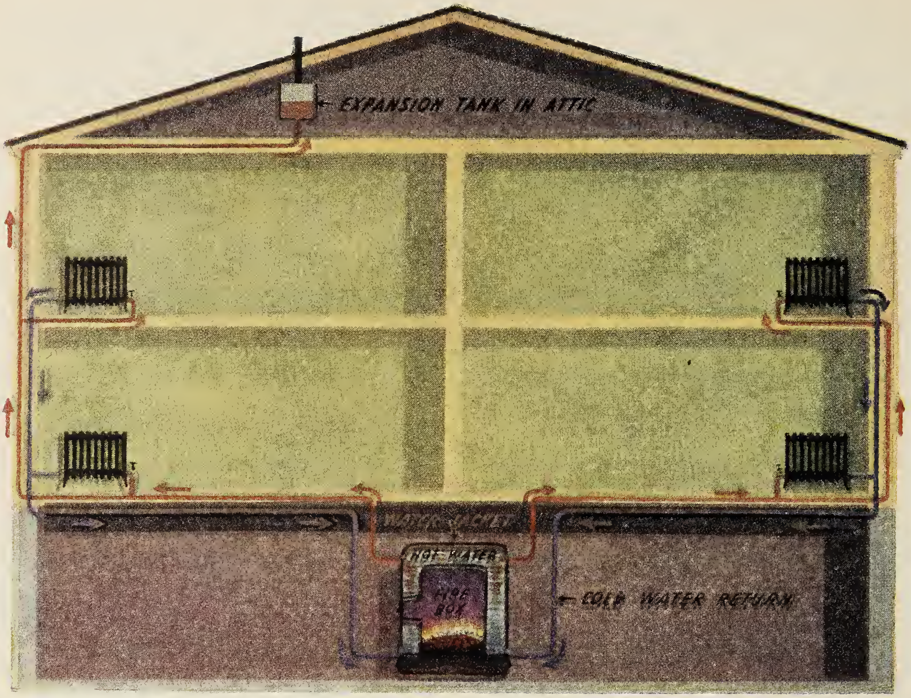
1. *Why does the colored liquid in a thermometer go up and down as the temperature changes?*
2. *Why is there a current in a jar of water when it is heated on one side?*
3. *If the radiator of an automobile is filled right to the top, what do you think will happen when the engine gets hot? Why?*
4. *When you put a kettle of water on the stove to heat, should you fill the kettle full? Explain your answer.*



How is hot water used to heat a house?

You now know two things that heat does to water. So you can understand how hot water is used to heat a house. Study the picture of a hot-water furnace on this page. Notice the firebox in which the fuel is burned. There are two walls of iron around the firebox. There is water between these walls. This space filled with water is called a *water jacket.*

Pipes run from the top of the water jacket up through the house. Other pipes run into the lower part of the water jacket. The pipes connect the furnace with the radiators that are in the rooms of the house. Look at the picture again. Find the pipes that run from the furnace to the radiators. Do you see the pipe that runs from each radiator back down to the furnace?

When there is a fire in the furnace, the water in the water jacket gets hot. The water expands and gets lighter. Upstairs the water in the radiators and pipes is cool. This heavy, cool water begins to sink down through the pipes marked with the blue arrows into the lower part of the water jacket. It pushes the lighter, hot water up through the pipes marked with the red arrows and into the radiators.

The heat from this water in the radiators goes into the rooms and makes them warm. As the water in the radiators gets cool, it contracts and gets heavier. It goes back down to the furnace where it is heated again. The water travels just as it did in the experiment with the sawdust in the jar of water.

If your home is heated by hot water, find out where the pipes are that carry the hot water up to the rooms. Find the place where the pipes carry the cool water back into the furnace. See how the pipes go to each radiator. Look carefully at your furnace and try to find out how it works.

1. *Why does water move through the pipes in a house heated by hot water?*
2. *Trace the current of water in the furnace on page 110 and explain how the upstairs rooms are heated.*
3. *In some houses, like the one on page 110, the hot-water pipes are connected to a tank in the attic. Why is this done?*
4. *Are the hot-water pipes connected to the top or to the bottom of the water jacket? Are the cold-water pipes connected to the top or the bottom of the water jacket? Why are they connected in this way?*

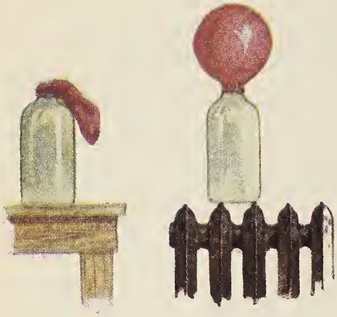
How do heating and cooling change gases?

YOU HAVE LEARNED that heat makes solids and liquids expand and that cooling makes them contract. Do you think that heating will make a gas expand and that cooling will make it contract? Suppose you try a few experiments to find out.

For your first experiment, stretch the neck of a toy rubber balloon over the mouth of a bottle. Heat the bottle in a pan of hot water or on a hot radiator. Watch the balloon. Why does it begin to swell?

You know that you must blow air into a toy balloon to make it swell. You know that some air went into the balloon in the experiment you just did. But where did the air come from? Of course, you know that there was air in the bottle. When you heated the bottle, you heated the air inside it. Some of this warm air went out of the bottle into the balloon. This shows that when air is heated it expands. So some of the heated air is pushed out into the balloon.

Leave the toy balloon on the bottle and put it outdoors or in some cold place. Watch what happens to the balloon this time. What happens



when the air in the bottle is cooled? When air is cooled, it contracts. The shrinking balloon shows how much less room the cold air takes up.

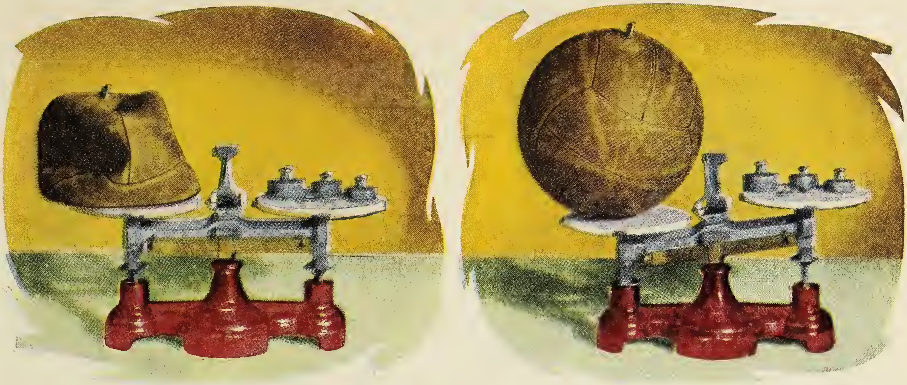
Try another experiment to make sure that air expands when it is heated. Find a bottle with a small neck. Put it outdoors or on some ice where it will get cold. Then fill a glass with water. When the bottle is cold, put its mouth straight down into the water in the glass. Hold both your hands tightly around the bottle so that the heat from them will warm the bottle and the air inside the bottle.

Do you see anything come out of the bottle? If nothing happens, you are not making the air warm enough. Be sure to keep the mouth of the bottle under the water.

You can probably explain why the bubbles came out of the bottle. When the air in the bottle was warmed, it expanded. It pushed out into the water and bubbled to the top. The bubbles were air. Again you have found that air expands when it is heated.

Use the same bottle and glass of water and do the experiment in just the opposite way. Get the bottle very warm by putting it in hot water. Then quickly put the mouth of the bottle straight down into the glass of water. Be sure to keep the mouth of the bottle under the water all the time. Take some ice and hold it around or on top of the bottle to cool the air inside the bottle. What happens? Can you tell why the water goes up into the bottle?

When the air inside the bottle is cooled, it does not take up so much room as it does when it is warm. The air outside the bottle pushes the water into the bottle to fill the place left by the air as it contracts. This happens because air contracts when it is cooled.



Does this picture show that air really weighs something?

Air expands when it is heated. It contracts when it is cooled. Of course, you remember that air is not a solid or a liquid. Air is a mixture of gases. All gases expand when they are heated. And all gases contract when they are cooled.

Now do another experiment to discover something else about air. When you have discovered this, you will be able to explain many things about heating your home. Get a basketball or a volleyball, a pair of scales, and a bicycle pump. Let all the air out of the ball and weigh the ball. Now take the ball off the scales and pump air into it until it is quite hard. Put it back on the scales. Is it heavier? Does air really weigh something?

Probably you have never thought that air has weight. But when you filled the ball with air, it was heavier than it was when it was empty. All materials have weight, and air is a material.

If you could fill the ball first with cold air and then later with hot air, you would find that the cold air weighs more than the hot air. Cold air is heavier than the same amount of hot air. Gravity pulls down with more force on the heavier, cold air.

You have now learned three important things about air.

1. Air expands when it is heated and contracts when it is cooled.
2. Air has weight.
3. Cold air is heavier than the same amount of hot air.

Knowing these things will help you explain why air acts the way it does. For your next experiment get a wooden box like the one in the picture on page 114. A box about twice as large as a chalk box will work well. You will also need two lamp chimneys and

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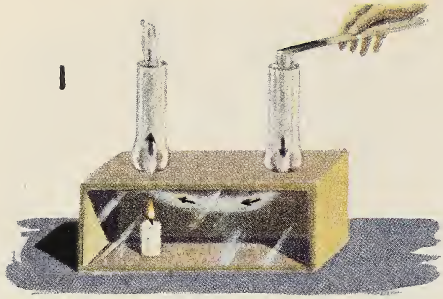

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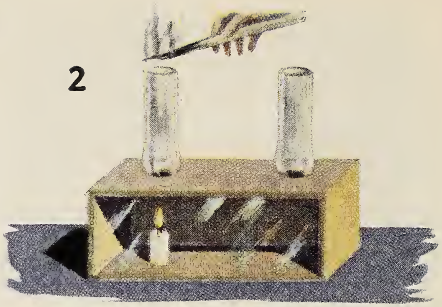

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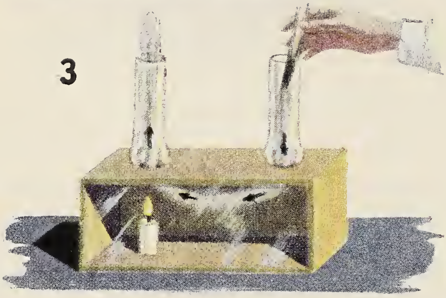

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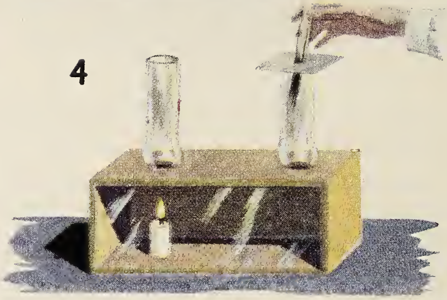

a piece of glass. Use cardboard tubes if you cannot get lamp chimneys.

Cut two holes in the top of the box and place a lamp chimney over each hole, as you see in the picture. Put a small candle in the box under one of the chimneys. Light the candle and cover the open side of the box with a piece of glass. Now light a splinter of wood or a roll of paper. Let it burn a moment and then blow out the flame.

With the splinter still smoking, hold it over the lamp chimney that has no candle under it (Picture 1). Where does the smoke go? Now hold the smoking splinter over the other chimney (Picture 2). Where does the smoke go? What does the smoke show you? If you see the smoke moving, you know which way the air is moving because the smoke is being carried by moving air.

Light the splinter again and blow it out. This time place the smoking splinter farther down inside the chimney that has no candle under it (Picture 3). What happens to the smoke in the box?

Now put a splinter through a piece of cardboard big enough to cover the chimney. Make the splinter smoke and put it down in the chimney that has no candle under it (Picture 4). Hold the cardboard tightly against the top of the chimney. What happens to the smoke now? Why has it stopped moving?

If you answer these questions, you will understand what has happened.

How did the heat from the candle change the air around the candle?

Which way did the air move in the warm-air chimney?

Which way did it move in the cool-air chimney?

The warm air went up, and the cold air came down. Can you tell why the cold air came down? This is the reason. When air is heated, it expands. So there is not so much air in the same amount of space as there was before the air was heated. Cool air is heavier than the same amount of warm air. Gravity pulls down harder on the heavier, cool air than it does on the warm air.

The air in the cool chimney is heavier than the air in the warm chimney. So the cool air sinks down into the box and pushes the lighter, warm air up out of the warm chimney.

When you covered the chimney with cardboard, the smoke did not move. So you can be sure that the air was not moving. The cardboard cut off the air from above the chimney and kept the heavier, cool air from moving down into the box. The smoke did not move. So you can be sure that the air did not move.

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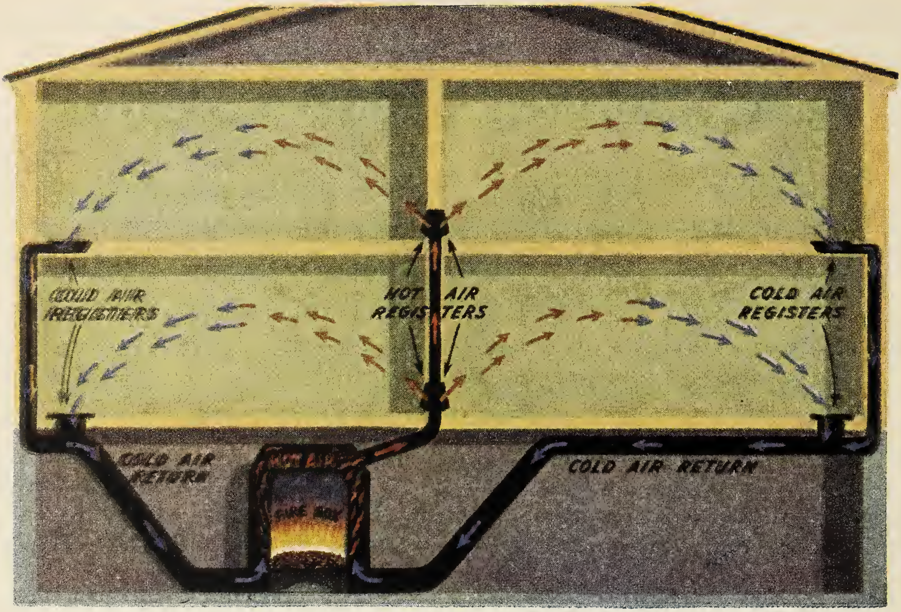
1. *One hot summer day, John and his father were riding in their car. Suddenly there was a loud bang. One of the tires on the car had blown out.*

   "I told the garage man not to put too much air in that tire," said John's father. "It's an old tire."

   Why was it not safe to put so much air in that old tire on a hot day?
2. *Each sentence below has a blank in it. Choose a word to take the place of the blank so that the sentence will tell something true about what heating or cooling does to gases.*
   - *a) Gases____________when they are heated.*
   - *b) Gases____________when they are cooled.*
   - *c) Cool air is____________than the same amount of warm air.*
3. *If a football is pumped up in a warm room and then taken outdoors on a cold day, will it get harder or softer? Why?*
4. *You have learned what heating and cooling do to solids, liquids, and gases. What two things happen to all of them?*



How does a hot-air furnace heat a house?

THE BATES FAMILY was getting ready to move into a new house. One afternoon, Betty's father said, "Let's go over and see our new house. I have just built a fire in the furnace."

By the time they got to the house, Betty was cold. As soon as they were inside, she went over to a grating at one side of the room. "I thought there was a fire in the furnace," she said. "There isn't any heat coming up through here."

"Of course not," replied her father. "That is a cold-air *register*. Over here is the place where the hot air comes up from the furnace."

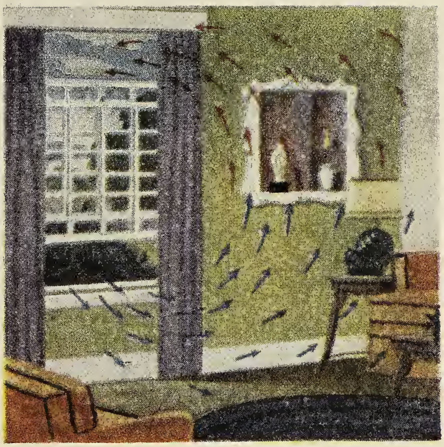
After a while, they all went down to look at the basement. Here Betty's father showed her the big pipe that brought cold air into the bottom of the furnace. She also saw the pipes that carried hot air up into the rooms.

Your experiments have helped you understand how the hot air and the cold air moved in Betty's house. The cold air was heavy. So it sank down the pipes to the bottom of the furnace and pushed up the air that had been heated. This hot air went up the pipes to the rooms. It came out of the hot-air registers and rose to the ceiling. Then it began to get cooler and heavier. It sank down through the cold-air registers into the pipe and then to the bottom of the furnace. In this way, the air was kept moving through the house and through the hot-air furnace.

Look at the picture on page 116 and see how the air moves. Are the arrows placed correctly to show how the air moves? What makes the air move up to the rooms? What makes it come back to the furnace?

Do an experiment to find out whether the air near the ceiling is warmer. Get two thermometers. Hang one up near the ceiling and place the other near the floor. In a few minutes, read both thermometers.

What you have just learned about hot and cold air will help you *ventilate* your bedroom. As you probably know, ventilate means change the air. This experiment will show you how to do it. Open one of the windows in your schoolroom at both the top and the bottom. Fasten several strips of paper to the top of a window pole. Then hold the pole so that the strips of paper are at the top opening of the window. Also hold some other strips of paper at the lower opening.



Watch the strips of paper to see which way they are moved by the air. How can you tell at which opening fresh air comes into the room? The fresh, cool air comes into the room at the lower opening and pushes the lighter, warm air to the top of the room and out at the top opening of the window.

You have learned how important fresh air is in keeping you healthy. A well-ventilated room is a much more healthful place than one that is not well-ventilated. At night, if you open your bedroom window at the top and also at the bottom, your room will have plenty of fresh air.

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1. *How does a hot-air furnace heat a house?*
2. *Trace the moving air in the picture on page 116 and tell how the rooms are heated.*
3. *How would you open the windows to ventilate a room? Explain why you would do it in this way.*

Which of these will melt first—the paraffin, the lead, or the ice?

How are solids changed to liquids?

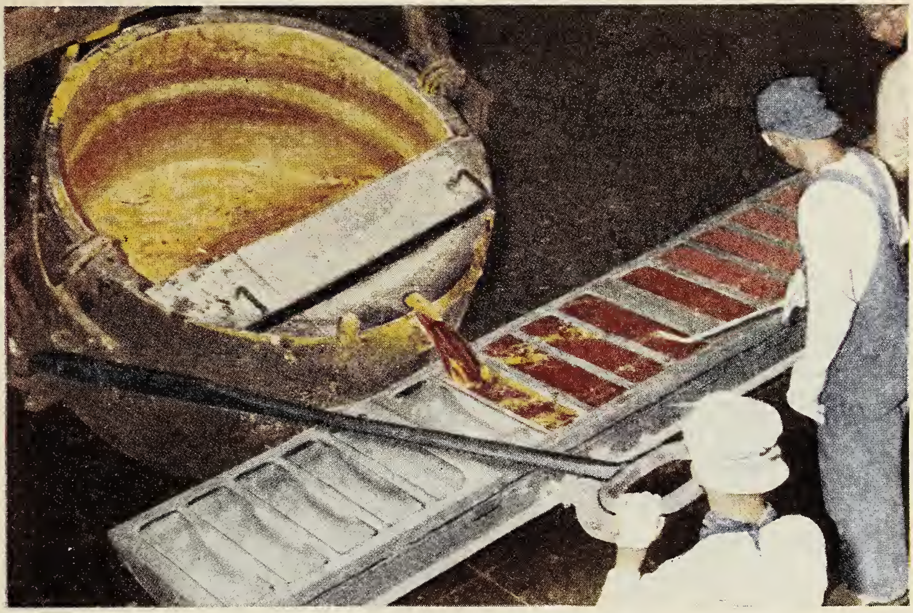
SUPPOSE YOU TRY this experiment. Take an iron pan and put in it a piece of hard butter, a piece of paraffin, a piece of lead, and a piece of aluminum. Put the pan over a hot fire. Which materials melt first? The butter and the paraffin melt first. Pour them out as soon as they have melted. The lead melts next. Did the aluminum melt? You could not get the pan hot enough to melt the aluminum or the iron of the pan. But you probably know that fires can be made so hot that they will melt iron and aluminum.

Many solids change to liquids when they get hot, but different kinds of solids melt at different temperatures. The temperature at which a solid melts or changes to a liquid is called the *melting point* of that solid.

Do you know what the melting point of ice is? You can find out if you try this experiment. Put a thermometer into a pan of melting ice. Look at the thermometer several times as the ice melts. If you were careful, you found that the melting point of ice is 32° F. (F. stands for *Fahrenheit,* the kind of thermometer we usually use. The little circle after 32 means degrees.) When the temperature of ice gets to 32 degrees Fahrenheit, the ice changes to water.

Lead must be heated to 620° F. before it will change to a liquid. Aluminum must be heated to about 2000° F. before it will melt. The big furnaces where iron is melted go to a temperature of over 2700° F. before the iron in them will melt.

When the melted materials get cool enough, they change to solids again. So we can melt solids and *mold* them into the shapes we want. Many of the iron things we use are made by melting iron and pouring the liquid iron into molds.



The red-hot aluminum is being poured into molds. When it cools, it will harden into solid pieces that have the shape of the mold.

Scientists have spent years and years experimenting to find out how to melt metals and to mold them into different shapes. The Indians found copper long before white people came here, but they did not make much use of it. They could only hammer it into shape with stones. They did not know how to melt it. So they could not pour it into molds to make things of different shapes.

We could not mix metals, either, if we did not know how to melt them. You have often seen pieces of brass. Brass is a bright yellow metal made by melting and mixing copper and zinc. Bronze is made by melting and mixing copper and tin. Bronze will not rust. It is harder than either copper or tin. Statues and other things that are outdoors all the time are often made of bronze.

---

1. *What do we mean by the* melting point *of a solid?*
2. *Why do we sometimes need to melt solids?*
3. *Why would lead be a poor metal to use for making cooking pans?*
4. *Why do we sometimes want to mix metals?*

How are liquids changed to gases?

IN WINTER, people put some alcohol or another liquid in the radiator of an automobile to keep the water from freezing. Perhaps you have heard someone say, "My radiator boiled yesterday, and I suppose the alcohol is all gone. I'll have to get some more."

Do you know what became of the alcohol? Do you know why the alcohol changed to a gas before the water did? If you boil some alcohol, you will understand why the alcohol changed to a gas and left the water behind. If you put a thermometer in water, the thermometer will show 212° F. when the water boils. But if you put a thermometer in alcohol, the thermometer will show 172° F. when the alcohol boils.

No matter how fast a liquid boils, it will not get any hotter than it is when it first begins to boil. When it boils, it is changing from a liquid to a gas just as fast as it can. The temperature at which a liquid boils is called its *boiling point*. The boiling point of water is 212° F., and the boiling point of alcohol is 172° F. Every liquid has its own boiling point.

When an automobile engine runs, the alcohol and water in the radiator both get warm. If they get as hot as 172° F., the alcohol will boil and change to a gas. But the water is not yet hot enough to boil. Some of the water will change to a gas, but it will not change very fast until it boils. It will not boil until it reaches 212° F. So most of the water stays in the radiator long after all the alcohol has gone out into the air.

But, of course, you know that you do not have to boil a liquid to make it change to a gas. Water is always changing from a liquid to a gas, or evaporating. This is what happens when water in an open dish or glass disappears. The water that is in the air is called water vapor. Water vapor is a gas. You cannot see it.

We get some of our supply of salt by evaporating water. The water in the oceans and in some big lakes, such as Great Salt Lake in the United States, has much salt in it. When the water evaporates, the salt is left behind. To get the salt, the water is pumped into large, flat basins. The water evaporates, and the salt can be shovelled up. The picture on the next page shows how salt is taken from the water in Great Salt Lake in this way.

You can do some experiments to find out more about how different liquids evaporate. Take two pans that are just alike and put exactly the same amount of water in each pan. Mark each pan to show just how high the level of the water is. Heat one of the pans slowly. Do not heat the other one. After half an hour look at the pans. Did heating make the

This white material looks like snow. But it is salt that was left when water from Great Salt Lake evaporated.

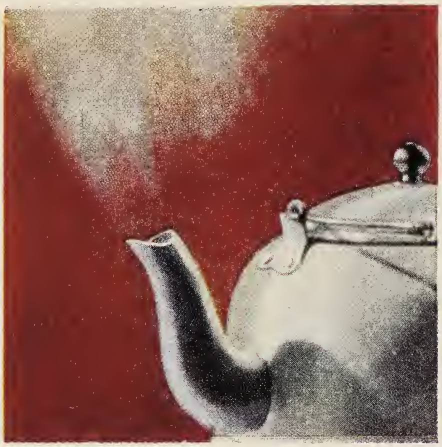
water evaporate faster in one of them? Why is it important to have the same amount of water in each of the two pans before you begin to heat one of them?

Now get two saucers that are exactly alike in shape and size. Put a tablespoonful of alcohol in one saucer and a tablespoonful of water in the other. Let them stand for an hour. Then measure the liquid in each saucer. Which liquid is evaporating faster? Scientists know that some liquids evaporate faster than others. Does gasoline evaporate more quickly than water? If you do not know, how can you find the answer to this question?

---

1. *Do all liquids boil at the same temperature? Give an example to explain your answer.*
2. *What does* evaporate *mean?*
3. *Will a hot fire make boiling water any hotter than 212°F.? How could your mother save fuel by knowing this?*
4. *Why will clothes dry more quickly if they are hung in the sun than if they are hung in the shade?*

How is water vapor changed to liquid water?



WATER THAT has evaporated into the air can be changed to a liquid again. Do you know how? Here is a picture of a teakettle full of boiling water. Look carefully at the picture. Can you see anything close to the spout of the kettle? This space that looks empty is really filled with steam. You cannot see it, because it is a colorless gas. Steam is very, very hot. It is water vapor that is at the same temperature as boiling water.

When the hot steam gets a little farther away from the hot kettle, it gets cooler and changes into very tiny drops of water again. These tiny drops make the white cloud a short distance from the spout of the teakettle. If you hold a cold plate in this cloud, the plate will soon be covered with water. How does this water get on the plate?

The steam, which is a gas, changes to liquid water when the steam is cooled on the cold plate. The air near the spout of the teakettle is also cool enough to change the steam back into tiny drops of water. We say that the steam condenses. Condense means change from a gas to a liquid. Cooling helps gases condense. Heating helps liquids evaporate.

Air always has some water vapor in it. If the air is cooled enough, some of the water vapor condenses. You may have seen this happen when you made a pitcher of ice-cold lemonade in the summer. The air around the pitcher is cooled. Some of the water vapor in it condenses. Tiny drops of water form on the pitcher. And if you blow your breath against a cold windowpane, the same thing happens. Your breath contains a great deal of water vapor. This water vapor condenses when it strikes the cold windowpane.

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1. *What does* condense *mean?*
2. *Before water vapor will condense, what must happen?*
3. *Have you ever seen steam? Explain your answer.*

QUESTIONS TO ANSWER

1. If very hot water is poured into a drinking glass, the glass will usually break. Why does this happen? What does this tell you about washing dishes?

2. Baking powder is often mixed in the flour to make biscuits or cake. When the dough is heated, the baking powder forms carbon-dioxide gas. The gas is trapped in the dough. As the dough is heated, it gets larger. Why?

3. Why does the ceiling above a radiator or register get dirtier than the rest of the ceiling?

4. Why do smoke and steam usually go up instead of down?

5. Why does water sometimes collect on windowpanes inside the house when it gets cold outside? Where does the water come from?

6. Wooden wagon wheels are usually fitted with iron rims. The rims are heated until they are very hot. Then they are slipped over the wheels and allowed to cool. Why are the rims heated before they are put on?

7. Sometimes we keep materials in bottles with glass stoppers. These stoppers often are hard to get out. How could you use what you have learned about heat to help you remove a glass stopper that was stuck tightly?

8. In a pond or lake, where will the warmest water be in summer? Where will the coldest water be? Explain your answer.

9. Why can you "see your breath" on a very cold day but not on a warm day?

THINGS TO DO

1. Find out what "dry ice" is. Probably a druggist can tell you. Make a report to the class.

2. Find out one reason why rivets are heated until they become red-hot when they are put into steel beams to hold the beams together.

3. Make a list of some things at home and at school that have been made by changing a solid to a liquid and then letting the liquid cool.

4. When water freezes, does it expand or contract? Make up an experiment to show that your answer is correct.

5. Find out whether water is different from other liquids in the way that it acts when it freezes.

6. If you can get a can of automobile antifreeze mixture, read the directions on it. Tell the class everything you learn about the directions.

7. Make a drawing of a room with a stove at one side. Show by arrows how the air currents move.

8. Make a pinwheel of paper. Hold it over a hot register, stove, or radiator. Why does it turn?

9. Find out how the Fahrenheit thermometer got its name.

We can tell when chemical changes
take place by the changes in the
characteristics of materials.

★ *In Unit Five You Will Learn* ★

★ How materials are different from each other ★
★ How we can change the characteristics of materials ★ What elements are ★
★ How elements are joined together ★ How we use chemical changes ★
★ How we can prevent harmful chemical changes ★

⋆ UNIT 5 ⋆

What Are Things Made Of?

DID YOU EVER find a piece of something and wonder what it was made of? Perhaps it was a stone with bits of white, yellow, and black materials in it. Or perhaps it was a piece of metal that was different from anything you had ever seen before. When you said to yourself, "I wonder what it is made of," you were asking a question that people began to ask many thousands of years ago.

Those people of long ago saw many of the same things happening that you see. They saw a big pile of wood burn and leave only a small pile of gray ashes. They saw bright iron swords turn to a dull brown color when they rusted. And they saw copper kettles change from brown to green. Red, juicy meat that was good to eat on one day would change color and be spoiled a few days later. If they ate the spoiled meat, they often found that it would make them sick. All this made them wonder what things were made of and why they changed.

Over 2000 years ago, a famous thinker lived in Greece. He decided that he knew what things were made of. He said, "Everything in the world is made of air, water, soil, and fire." Why do you suppose he thought that? He knew that living things need air and water to live and to grow. So he decided that many things must have air and water in them. He knew that plants grow out of the soil and that animals need plants for food. He thought that there must be some soil in all living things.

Fire was a mysterious thing that no one could understand. It seemed to come out of wood, cloth, and other materials when they burned. So the wise man decided that there must be fire in many things in the world, too.

The famous Greek thinker of long ago thought that everything in the world must be made of these four things—air, water, soil, and fire. For hundreds of years, people believed that this was true.

Then people began to look at things

more carefully and to do experiments. So they began to find the right answer to the question "What are things made of?" We still do not know all of the answer to this question. But scientists are working all the time to find out more about how things are made.

When you study this unit, you will learn more about materials than the wisest men knew in the days of the great Greek thinker. You will learn what things are made of and what happens when materials change. A good way for you to begin is to look at some of the things that you see and use every day. The many things that you find out about materials will probably surprise you.

How are materials different from each other?

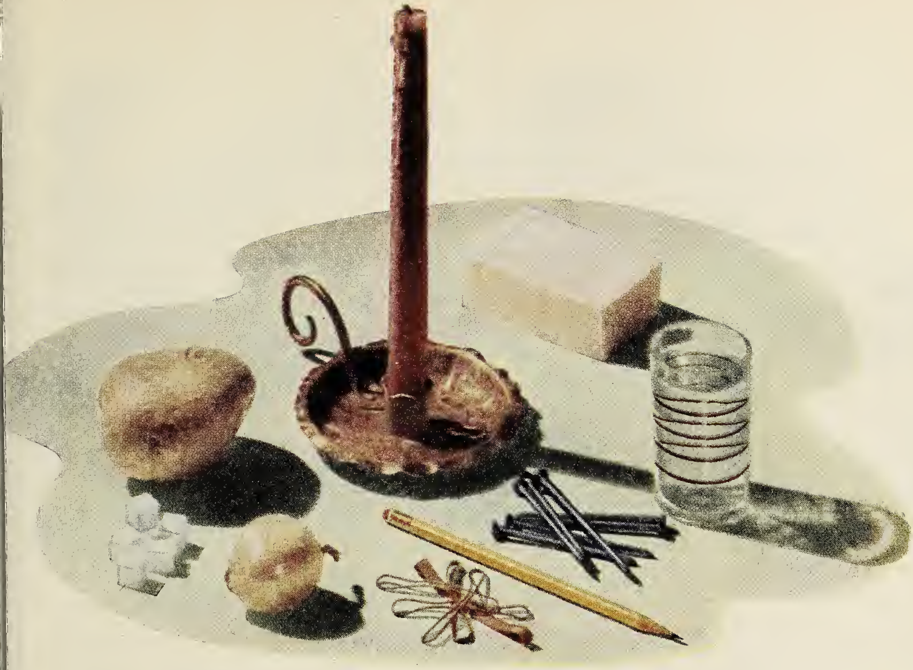
SUPPOSE EACH ONE in your class brings two or three things made of different kinds of materials to study. Here are some of the things that one science class brought—a piece of coal, a lump of wax, vinegar, water, buttons, wood, stone, rope, milk, nails, a tin can, maple syrup, salt, an apple, and some sugar. Henry even brought a bottle of carbon-dioxide gas. His father owned a drug store, and he told Henry that carbon dioxide is used to make the "fizz" in soda water. He took some of the gas from a big steel tank and put it into a bottle so that Henry could carry it to school.

When you have your collection of materials ready, separate them into three groups—solids, liquids, and gases. Then look at each kind of material carefully to find out what it is like. Look for things that will help you describe the materials to someone else. Feel them, look at them, smell them, and squeeze them. You may try to pull them apart and try to bend them. Ask your teacher which materials are safe to heat and taste. But you must be careful not to heat or taste materials unless you know what they are. The material might explode, or it might be poisonous. Never heat or taste any material unless your teacher says that it is safe to do so.

While you are looking at these materials, write on the blackboard or on a piece of paper the different words you would use to tell what the materials are like. When you get through, you should have a list somewhat like this one that one class made.

Hard
Soft
Springy
Brittle
Sticky
Watery
White
Black
Sour
Sweet
Colorless

Rough
Smooth
Easy to melt
Hard to melt
Can be stretched
Can be bent
Can be squeezed
Strong
Weak
Shiny
Dull



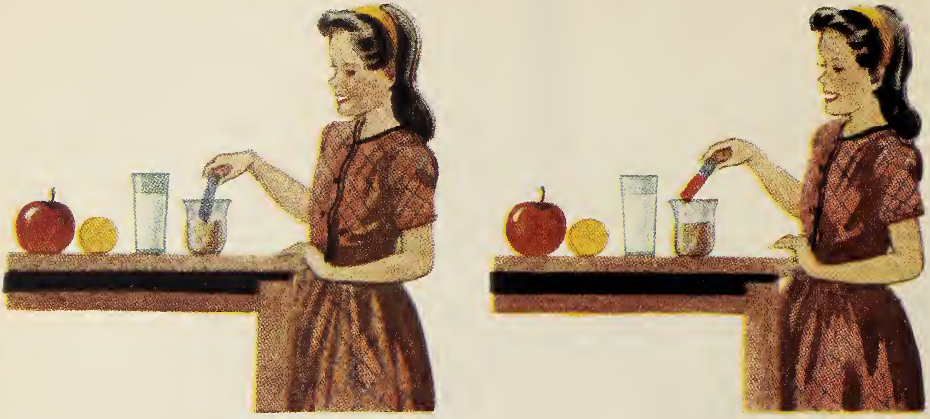
What materials do you see in this picture? What are some of their characteristics?

Write this sentence at the top of your list. "These are some of the *characteristics* of materials."

Do you know what the word characteristics means? When we want to describe a person, we tell what his characteristics are. Perhaps you have blue eyes, dark-brown hair, freckles on your face, and a little scar on your finger where you cut it last month. These are some of your characteristics. They describe you. Other people know who you are by these characteristics. Each kind of material has characteristics of its own that tell us what the material is like.

The way we use a material depends on its characteristics. What characteristics of glass make it good for windows? You can probably answer this question very easily. First of all, you know that you can see through some kinds of glass. Then, too, glass will not soak up water. If it did soak up water, windows would get soaking wet every time it rained.

The boys and girls in the science class were examining all the materials they had brought to class. They wanted to find the important characteristics of each material. They stretched a rubber band, and the band



What happened to the blue litmus paper when the girl put one end into some vinegar?

snapped back when they let go of it. They had found that rubber is *elastic,* or springy. They squeezed a piece of cotton and a sponge and saw that they could make these take up less room. This showed them that cotton and sponges could be *compressed,* or made smaller by squeezing.

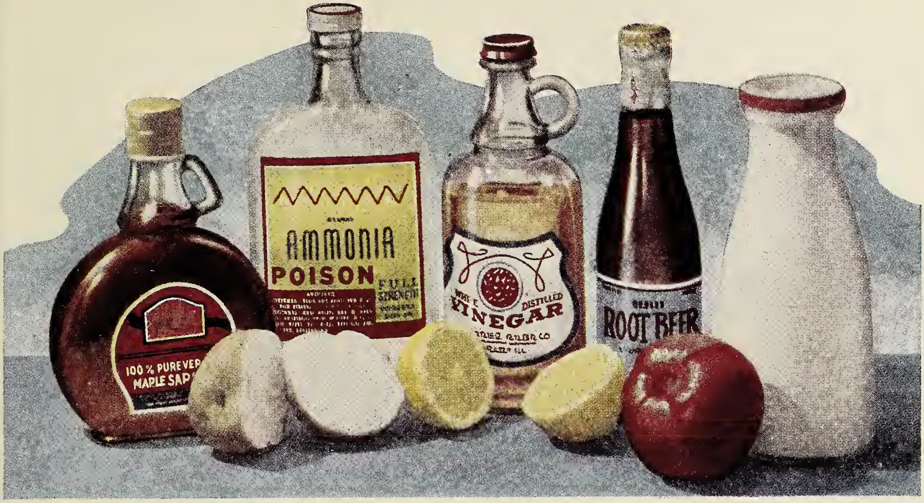
As the boys and girls were finding the characteristics of the different materials, something funny happened. Jane saw some brown liquid in a jar. She asked the teacher if it would be safe to taste it. When Jane was allowed to taste it, she swallowed a spoonful of it. You should have seen her face! The liquid was vinegar, and Jane learned one of its main characteristics. It is *sour.*

The boys and girls knew that it was dangerous to taste a liquid if they did not know what it was. The liquid might be poisonous. So the boys and girls asked if there was a safe way to find out whether anything is sour.

"Yes, there is a safe way," said the teacher. "Everything that is sour has *acid* in it. I'll show you how a scientist tests a material to see whether it has acid in it. He doesn't have to taste it."

She got a strip of paper called *litmus paper.* This litmus paper was blue. She put one end of the litmus paper in a small amount of vinegar. When she took it out, the end that had been in the vinegar had turned from blue to red. A scientist knows that anything with acid in it will turn blue litmus paper red.

The boys and girls tested other things. They cut a lemon in half and put one end of the blue litmus paper against the cut surface of the lemon. The lemon turned the paper red.



How can you find out which of these materials have acid in them?

This showed that the lemon had acid in it, too. Then they mixed some baking soda in water. When the blue litmus paper was put into this, it did not turn red. Is there acid in baking soda?

Safety rules for handling materials

1. Never taste anything if you do not know what it is.
2. Never heat materials unless you know that they will not explode.
3. Never mix materials that may explode or burst into flame.
4. When you are heating a material, clear away everything that may catch fire.
5. If you get an acid that burns on yourself or your clothes, wash it off quickly. Baking soda dissolved in water is good to use.

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1. *What characteristics of iron make it a good material for bridges?*
2. *Tell how you would find out whether oranges and apples have acid in them.*
3. *What characteristics of wood make it a good material for furniture?*
4. *Compare the characteristics of cellophane and tissue paper. Why is cellophane better than tissue paper for wrapping food?*

How can we change the characteristics of materials?

Suppose you take two or three of the materials that you have brought to school and try to think of ways in which you can change some of their characteristics. How could you change the characteristics of water? Right away, you may think of freezing it and of boiling it. When you freeze it, it changes from a liquid to a solid. When you boil it, it changes from a liquid to a gas. Solid blocks of wax or paraffin like those in the picture can be changed to a liquid by heating them. A piece of lead will change to a liquid if you make it hot enough.

But what happens to liquid wax when it is poured onto some cool jelly? And what happens to melted lead when it cools? Does the water, the wax, or the lead change into a new material when it is heated or cooled? No, it does not. The lead is still lead, the wax is wax, and the water is water, no matter whether they are solid, liquid, or gas. A change like this is called a *physical change*. The material changes its form or shape, but it does not change into a different kind of material.

You know that some materials can be dissolved in liquids. You have dissolved sugar in water when you were making lemonade. And probably you have dissolved salt in water, too. If you tasted the water, you could tell that the sugar or the salt had not been changed into something else. They were still the same materials, even though they had been dissolved in water. The change that takes place in materials when they dissolve is a physical change.

Now let us do an experiment to show a very different way in which we can change materials. Fill a test tube about one-fourth full of sugar. If you haven't a test tube, use a metal lid from a jar or can. Heat the sugar for several minutes. Watch closely to see what happens. The white sugar turns to a brown liquid. Then you can see a white material coming from it. After a few minutes, a black material is all that is left. What do you think happened?

You have changed the sugar into something entirely different. The material left in the test tube has none of the characteristics of sugar, because it is no longer sugar. Sugar is white, but this new material is black. If you cool this black material and taste it, you will find that it is not sweet. When you dissolve sugar in water, you do not change it into anything else. But when you heat sugar, you change it into a different material.

You have often seen other changes that make new materials. You have seen bright, shining iron or steel changed to a brown, rusty material. Perhaps you have lost a pocketknife and have found it out in the yard several days later. You can easily rub off some of the brown rust with your fingers. Or perhaps you have seen an old tin can that has been outdoors for a year or more. You know that such a can is full of holes and that it is soft and crumbly. We say that the can has rusted. A new material has been made out of the material of the can.

The changes that happen when sugar is heated and when iron rusts are very different from the changes that happen when you melt wax or lead or when you evaporate water or dissolve salt in water. The heated sugar changes into something else. And the rusted iron becomes something different. New kinds of materials are made.

These new materials are different from the old materials. This kind of change is called a *chemical change*. When a chemical change takes place in a material, it changes to a new material. This new material has characteristics that are different from the characteristics of the old material.

You have seen chemical changes going on around you ever since you were old enough to notice them. In autumn, when leaves turn from green to red, yellow, orange, and brown, a chemical change has taken place in the leaves. Different materials have been made inside the leaves. When you find a piece of soft, brown, crumbly, decayed wood, you are looking at something that has been made by a chemical change. The hard yellow or

What chemical changes are taking place in this picture?

white wood that could have been made into a piece of furniture has been changed into something else.

Every time you light a fire, you start a chemical change. Burn a small splinter of wood in a metal pan. Be very careful to see that there is nothing near the pan which can catch fire. Watch the piece of wood change. After part of the splinter has burned, put out the flame. What has become of part of the wood? What color is the stick where it was partly burned?

You can see that a chemical change has taken place, because the gray ashes and the black material are very different from the piece of wood. A big piece of hard, black coal changes into a little pile of soft, gray ashes when it burns. The ashes are very different from the coal that burned.

Chemical changes are taking place inside your body all the time. Your body is like a chemical factory. Some of the food that you ate today is being changed into part of you. This is a chemical change. Put a small piece of bread or a cracker into your mouth and chew it for a long time. How does the taste change? If you hold it in your mouth long enough, the starch in the bread or the cracker will change into something that tastes sweet. This is one of the chemical changes that make the food ready for use in your body.

Every day, meat, potatoes and other vegetables, milk, fruit, eggs, and other foods are being changed into blood, muscles, bones, and teeth. You could not live if the food you ate were not changed into part of you.

Remember that there are two kinds of changes that can take place in materials.

1. When a material changes in form or shape but does not change into a new material, scientists say that a physical change has taken place.

2. If a material changes to a new material, they say that a chemical change has taken place.

1. *How is a chemical change different from a physical change? Give an example of each kind of change.*
2. *When you peel potatoes, do you cause a chemical change? Explain your answer.*
3. *Why is burning a piece of wood a different kind of change from melting a piece of iron?*
4. *What do chemical changes do to materials?*
5. *How are the characteristics of wood different from the characteristics of wood ashes?*
6. *After a chemical change has turned the green leaves to their autumn colors, what characteristics of the leaves are still the same? What characteristics are different?*
7. *Why are chemical changes important to you?*

What are elements?

WHAT DO YOU think happened to the sugar when you heated it? And what is the brown material that you rub from a rusty knife? Before you can answer these questions or understand the other chemical changes that take place around you, you will have to know what *elements* are and what we can do with them.

You remember that a famous man of long ago thought that everything in the world was made of just four things—air, water, fire, and soil. He called these things elements. But scientists now know that air, water, fire, and soil are not elements at all. They have found 98 different elements. All the different things in the world are made of these 98 elements.

Each of these things has in it a large amount of the element named near it.

You have seen some of these elements. You have seen iron, gold, copper, lead, silver, nickel, and aluminum. Perhaps you have also seen mercury, or quicksilver, and sulphur. These are elements, too. You will never see some of the 98 elements, because they are colorless gases. The oxygen in the air is one of these colorless elements. The air also contains nitrogen and small amounts of several other colorless gases that are elements.

You probably will never see some of the other elements, because they are so scarce. Some elements are so very scarce that you would never find them unless you went to some great science laboratory to see them.

Collect as many different elements as you can find. Label them and put them on a shelf for an exhibit. One science class was able to find eleven elements. They had lead, iron, copper, gold, silver, nickel, aluminum, and sulphur. To get two other elements, zinc and carbon, one of the boys took an old electric cell apart. The thin sheet of gray metal around the cell was zinc. The black rod in the middle was carbon. One boy brought an electric-light bulb. His father had told him that the wire inside was made of an element called tungsten.

Do you know why we call these materials elements? If you look in the dictionary, you will find that element means the simplest material from which other materials are made. Iron, silver, copper, lead, and the other elements are the simplest materials in the world. You can take one of these elements, such as iron, and crush it, grind it into the finest kind of powder, heat it, or dissolve it in liquids. But you cannot find any material in it except iron. For this reason, we call it an element. An element is made only of itself, not of two or more materials put together. Iron is made only of iron. Gold is made only of gold.

All the things in the world are made of these 98 elements. The next time anyone asks you the question "What is it made of?" you can be sure you are right if you say, "It is made of one or more elements." Some materials, like water, carbon dioxide, and salt, are made up of only two elements. Others, like sugar, washing soda, and alcohol, are made of three elements. There are many materials that are made of more than three elements. Pure baking soda has four elements in it.

1. *How is an element different from other materials?*
2. *Why can some of the elements not be seen?*
3. *How many elements have scientists found?*
4. *When is a material not an element? Give some examples.*
5. *Name some elements you have seen.*

How are elements joined together?

THINK CAREFULLY again about what happened to the sugar when you heated it. A black material stayed in the test tube. A white material went out of the test tube. Do you think that sugar is an element? It looks as if the sugar has been changed into other materials. That is exactly what has happened. The black material left in the test tube was the element carbon. The white material had two elements in it—hydrogen and oxygen.

So you see that sugar is a material that is made of simpler materials. Sugar is a *compound.* It is made of three elements—carbon, hydrogen, and oxygen. A compound is a material made of different elements joined together.

When the boys and girls in the science class were talking about this,

Have the sulphur and iron combined to make a new material? Why do you think so?

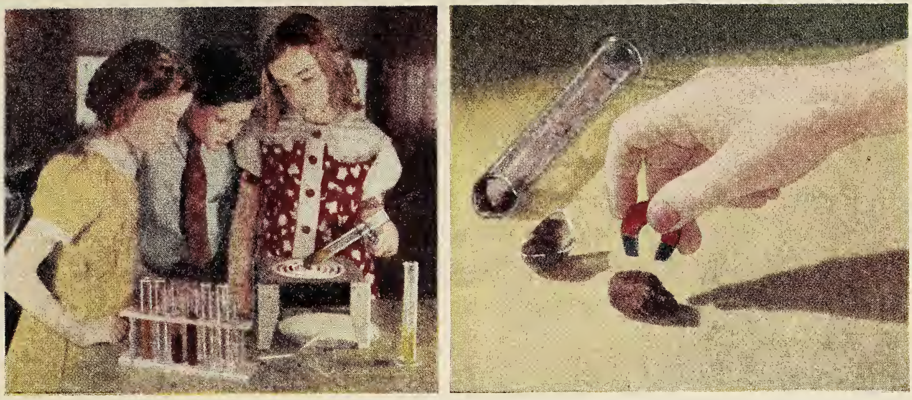
Nancy said, "I think I saw some carbon this morning. I was helping my mother get breakfast, and I forgot about the toast in the oven. When I looked at it, the toast was black. So I think that was carbon."

Two colorless gases and a black solid can make white, sweet sugar. This happens when a chemical change takes place. A chemical change makes an entirely different material. The new material has characteristics that are different from the characteristics of the elements that joined to make it.

Water is made of two elements—hydrogen and oxygen. These elements are colorless gases. When hydrogen and oxygen are joined together in just the right way, they form the liquid water. The characteristics of water, which is a liquid, are different from the characteristics of hydrogen and oxygen, which are gases.

Scientists have found only 98 elements. But these elements can be joined together, or *combined,* to make many different kinds of materials. No element will combine with all the other elements, but most of the elements will combine with several other elements to make compounds. Some compounds are made of only two elements. Others are made of several elements.

Whenever compounds are made, the elements do not just mix with each other. They combine with each other to make the compound. Take some powdered sulphur and some powdered iron. Shake the two elements together in a test tube. You are not making a compound. You are making a mixture. Pour the mixture out on a table and hold a magnet in the mixture. The fine pieces of iron stick to the magnet. The sulphur is left. Why does this show you that you did not make a compound?



What has happened to the iron and sulphur now? How do you know?

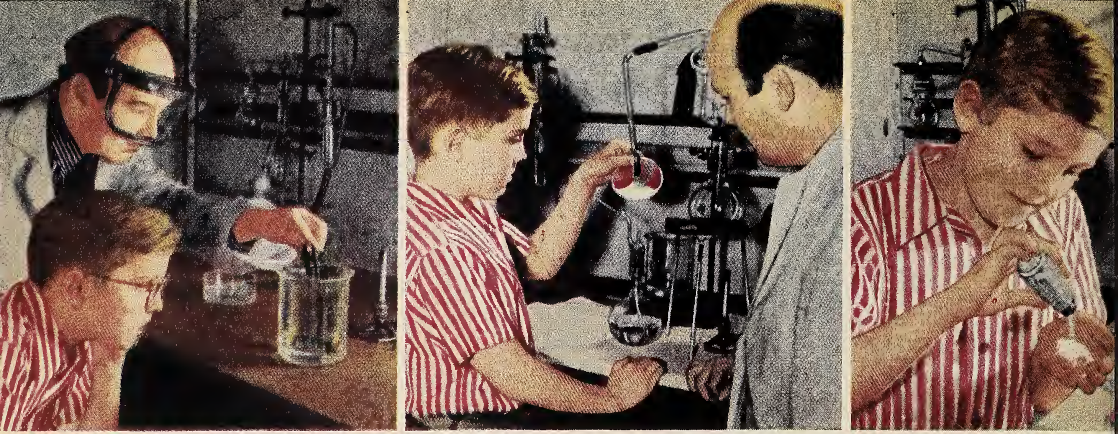
Put the mixture back in the test tube and pour water into the test tube. Still you have not made a compound. The sulphur rises to the top of the water, and the iron sinks to the bottom. The two elements have not been combined with each other. They have only been mixed with each other.

Let us see if we can make these two elements combine. Put exactly twice as much sulphur as iron into a test tube and stir them together. Hold the test tube over a flame and heat the two elements until they are very hot and seem to be combined. Cool the material and remove it from the test tube. You may have to break the test tube to get the material out. Wrap a cloth around the test tube first so that you will not get cut.

Test the material with the magnet. Does the magnet still pick up the iron? Put the material in water. Does it sink? The iron and sulphur have combined to form a compound that is different from either iron or sulphur. So the magnet can no longer attract the material. This material is no longer just iron and sulphur. It is a compound called iron sulphide.

Now let us learn about some other compounds. The element iron is a hard, silver-gray metal. When it rusts, it combines with some oxygen from the air and changes to a soft, crumbly, brown material. When someone asks you what iron rust is, you can tell him that it is a compound made of iron and oxygen. Bring a piece of rusty iron to school and look at it. Notice how soft the rusted part is.

Did you ever see copper that had been outdoors for a long time? It had probably turned to a dull, greenish color. If you scraped the dull material off with a knife, you found the shiny copper underneath. The outer



The picture on the left shows how a piece of sodium sends up a flame when it is dropped into water. In the centre, you can see how the greenish gas, chlorine, takes the color out of a red piece of paper. But when these two elements combine to make a compound, you can have salt coming out of a shaker.

covering was a material made of copper, carbon, and oxygen. These three elements combined to make a material that was not like copper, carbon, or oxygen. It was a compound of copper, carbon, and oxygen called copper carbonate.

Every day you use a compound that is made of two very dangerous elements! This compound is white. You probably use it on an egg at breakfast. Your mother uses it in cooking almost everything. It is salt! Salt is made of two elements. One of these elements is a bright, soft, silvery metal called sodium. If you put a piece of it on your tongue, it would burn your tongue badly. The other element is a greenish gas called chlorine that has a very bad odor. It is poisonous!

But when these two elements are combined by a chemical change, an entirely different material is made. This new material is not poisonous, it will not burn your tongue, it has not a bad odor, and you need it in your body. The chemical change makes a compound that is very different from the two elements that are in it. Scientists call it sodium chloride, but we call it salt.

If your house is painted white, it may be covered with a compound made of the two elements zinc and oxygen. When iron and oxygen combine, they make the brown material that we call iron rust. But when zinc and oxygen combine, they make a compound that is a white solid called zinc oxide. It is ground into a fine powder and mixed with oil to make one kind of white paint. It is also used to make a kind of salve.

Did you ever hear of a kind of paint called red lead? Perhaps you have seen men painting iron bridges or other iron with this bright red paint. It is made of a compound of lead and oxygen.

Everything in the world is made of elements and compounds. So, of course, your body is made of elements and compounds. Scientists have figured out that there is enough iron in a person's body to make a good-sized nail. There is enough phosphorus in your bones and teeth to make a match. Of course, you know that the iron in your body is not solid iron as a nail is, and you know that the phosphorus will not blaze up as a match will. The phosphorus and iron are in compounds in your body.

Your bones and teeth have in them another element called calcium. Milk is good food for making bones and teeth because it has much calcium in it. Calcium combines with phosphorus and oxygen to make a compound called calcium phosphate. Your body is made up of many other elements and compounds. You will learn more about them later.

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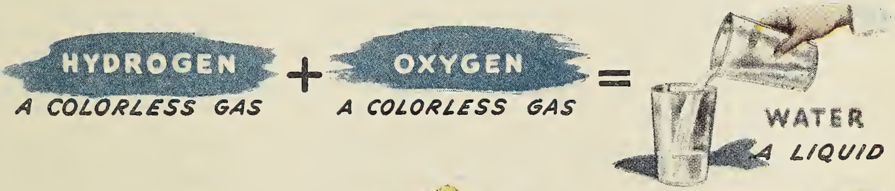
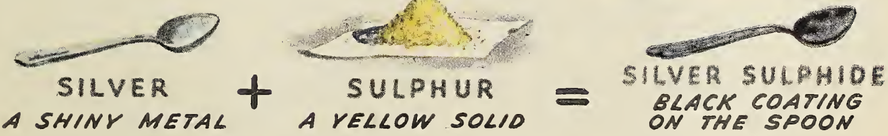
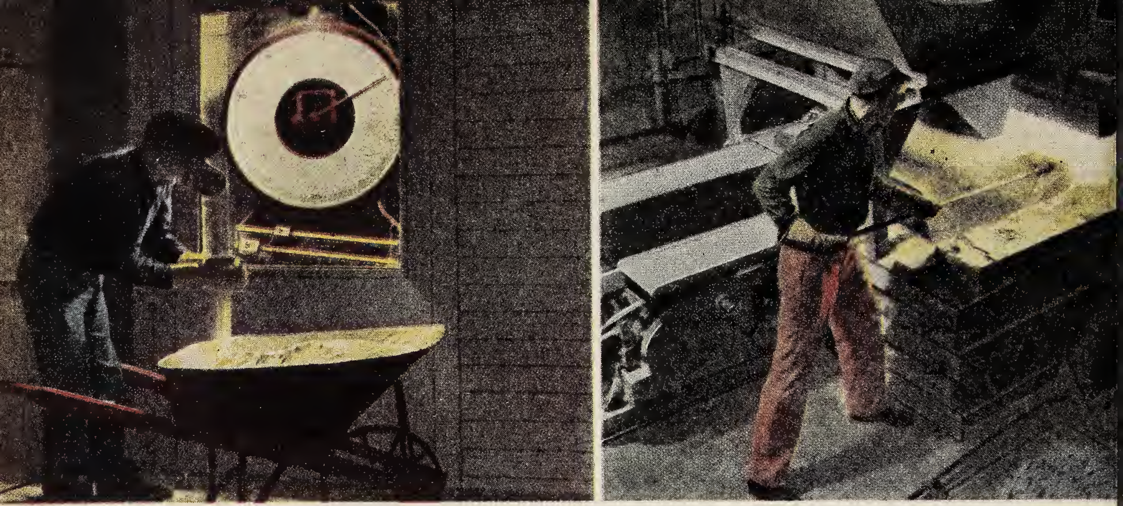
1. *Which is the best statement? A compound is made of (a) one element, (b) two elements, (c) three elements, (d) more than one element.*
2. *How are compounds different from elements?*
3. *Many chemical changes are mentioned in these pages. Make a list of the ones you know about. After you have made your list, complete this sentence: "I know that these are chemical changes because ____________"*
4. *Explain the difference between mixing two materials together and combining two materials. How could you do an experiment to show what this difference is?*
5. *Do you think that a chemical change takes place in milk when it sours? How could you use litmus paper to show that your answer is correct?*







In the picture on the left, sand and the other materials for making glass are being weighed. In the other picture, the mixture that will be changed into glass is being put into the oven to be melted.

How do we use chemical changes?

YOU HAVE LEARNED that chemical changes are happening all around you and that they are very important. All over the world today, scientists are studying the things that are in the earth and on the earth. They are finding ways of putting elements together to make new compounds and of taking compounds apart to make many kinds of new materials. These new materials are different from the elements and compounds that were used to make them. The new materials have characteristics that make them more useful to us.

Let us see how chemical changes are used to make some of the materials we need for building houses. The window glass that is letting light into your schoolroom was made mainly from sand. It is easy to see that sand must be changed before it can be made into glass. You cannot see through sand, but you can see through the glass. Scientists have found out how to make glass by mixing other materials with sand. When this mixture is heated until it is very hot, it melts. Then chemical changes make it into a new material with new characteristics. This is glass.

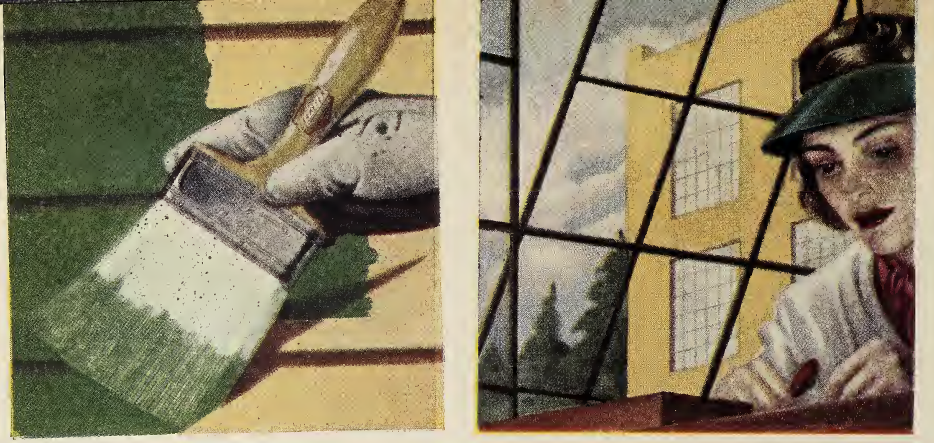
Streets and sidewalks are often made of concrete. Concrete is made by mixing the right amounts of water, sand, and cement together. As the mixture hardens, chemical changes take place that produce an artificial stone. Walls of buildings are plastered. Plaster is made from lime and sand. When water is added to lime, it gets very hot. You can see it bubble as the chemical change takes place.

Many of the things you use every day have been made by chemical changes. Paper is made by a chemical change. You cannot find paper growing, and you cannot dig it from the ground. Most paper is made from trees. The trees are cut, and the wood is ground up into a pulp. Materials are then added to the pulp, and a chemical change takes place. This change makes the material for paper. You could never make a book from the wood as it comes from the tree. But after the chemical change takes place, a new material is made. This new material is paper for books, newspapers, magazines, and many other things.

You have probably heard people talk about things made of *plastics*. Plastics are materials that can be formed, or molded, into different shapes when they are hot. When they cool, they get hard and keep these shapes. Plastics are made from other materials by chemical changes. There are too many plastics to name them all, but you already know the names of some.

Celluloid was one of the first plastics. Ping-pong balls are usually made of celluloid. Many things, especially foods, that you buy at the store are wrapped in *cellophane*. Perhaps you have some dishes made of *bakelite* or a comb made of a clear, transparent material called *lucite*. Fountain pens and combs are often made of lucite or some other kind of plastic. Plastics are used for much bigger things, too. They are very strong and do not break easily. Parts of airplanes, automobiles, furniture, and even water pipes are made from plastics.

These pictures show you three steps in making paper. In the picture on the left, the logs are being sent to the grinders to be ground into wood pulp. The centre picture shows what wood pulp looks like before it is made into paper. The last picture shows the paper.



The bristles of the paint brush are made of nylon. Another kind of plastic was used instead of glass in this window.

Some plastics are drawn out in threads and woven into cloth. *Rayon* and *nylon* are plastics of this kind. If your mother is wearing a dress made of rayon, she is wearing cloth that was probably made from wood. If she has some nylon stockings or a nylon blouse, she is wearing cloth made from coal, air, and water.

Besides cloth for clothes, nylon is used for many common things. Perhaps you brush your teeth with a toothbrush that has nylon bristles on it. When you go fishing this summer, you may use a nylon fish line. Nylon fish lines are so strong that you will not lose a big fish because your line breaks.

Your mother uses chemical changes at home, too. When she bakes a cake, she often uses baking powder to bring about a chemical change that makes the cake light. If she uses sour milk when she bakes a cake, she uses another chemical change. She adds baking soda to the sour milk, which has acid in it. When she puts the baking soda into the sour milk, a chemical change takes place. A gas is formed that makes the cake light.

Your mother then bakes the cake. The heat expands the gas, and the cake rises. If she burns gas, wood, coal, or oil in the stove, she is using the chemical change of burning to get the heat that bakes the cake.

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1. *Make a list of building materials made by chemical changes.*
2. *Make a list of clothing materials made by chemical changes.*
3. *Which of these materials are made from other materials?*
   Wood Wool Aluminum Copper Iron Steel Glass
   Cotton Bricks Plaster Rubber Leather Linen Gasoline
4. *How do you know that cooking often causes chemical changes?*

The sailors are kept busy painting the funnels and other metal parts to keep them from rusting.

How can we prevent harmful chemical changes?

PERHAPS YOU THINK that all chemical changes are useful to us. But if you think carefully, you may find that some of them are harmful.

Can you think of some chemical change that you may want to stop? You probably will think of rusting. Bridges, automobiles, skates, bicycles, nails, and other things made of iron and steel would soon be useless if we did not do something to keep them from rusting. Do you know how to keep them from rusting? If you think carefully, you will say that we must keep oxygen away from them. But how can we keep oxygen away from them? Just cover the iron and steel with something that will keep away the oxygen that is in the air. Paint is used to cover these metals.

Try this experiment and see what happens. Put some iron nails or some pieces of steel wool in a dish and keep them damp by sprinkling them with water. Put some other iron nails or steel wool in a dry dish. Look at them a few days later. Which ones are rusty?

Iron or steel rusts more quickly when it is damp. That is why we must be careful to keep tools and machines made of iron or steel dry.

One way of keeping foods is to dry them. In this picture, apricots are being dried in the sun. Can you think of some other foods that are preserved by drying?

Perhaps you wipe your skates with oil or grease to keep them from rusting during damp weather. The oil or grease keeps both air and moisture from the skates. Steel tools are often covered with oil or grease to keep oxygen and moisture away from the metal.

If you touch a tin can with a magnet, you will find that the magnet attracts the can. Tin, as you know, is not attracted by a magnet. So how do you explain what happened? Tin cans are not made of tin. They are made of steel. Steel rusts easily, but tin does not rust. So the steel can is coated with a layer of tin to keep the oxygen away from the steel.

Ash cans and garbage cans are usually made of a material called galvanized iron. This is steel covered with a layer of zinc. Zinc does not rust. We can stop harmful chemical changes by keeping materials that cause chemical changes away from materials which we do not want changed. This is what we do when we paint or varnish woods and metals and when we put a layer of some other metal over iron or steel.

Perhaps you have noticed that cans or bottles which have a powder in them are often labelled "Keep dry." Let us see what happens to some baking powder when it is not kept dry. Put a spoonful of baking powder into a cup or glass. Now add a spoonful of water. At once, something happens. The mixture begins to fizz. Hundreds of tiny bubbles of gas are given off. A chemical change is taking place. As long as the powder was dry, no chemical change took place. As soon as water was added, the chemical change started. So when you see a bottle labelled "Keep dry," you will know what to do to keep a chemical change from taking place.

Another chemical change that we usually do not want is the spoiling of food. Food is spoiled when bacteria grow in it and cause a chemical change. Bacteria grow best where it is warm. So keeping food cool is one of the best ways to keep it from spoiling.

Milk will sour very quickly unless it is kept in the icebox. But it will stay sweet for several days if it is kept cold. The decaying of meats and vegetables is another chemical change that we like to prevent. So we keep these foods in the icebox to prevent them from changing.

Sometimes we want to keep food fresh for a long time. We may want to ship it to distant places, or we may want to keep it to use later. One way to do this is to freeze food. Freezing keeps the bacteria from growing. As long as the food is kept frozen, it will not spoil.

You remember that bacteria are tiny plants. Like all plants, they need water to grow. So keeping water from them is another way to keep them from growing in food. Many foods are preserved by drying. Prunes, apricots, and other fruits are often dried. Can you think of some other foods that are preserved this way?

Did you ever have some of your colored clothes fade? The colors changed from bright to dull. If you have wallpaper on the walls in your home, look behind some picture that has been hanging in the same place for a long time. Is the color of the paper behind the picture the same as the color of the rest of the paper? What do you think makes the wallpaper change color?

Many materials fade because they are in the light. Sunlight makes chemical changes in the coloring material that was used to color the cloth or the paper. Many medicines are put in dark bottles to keep out the light that may cause chemical changes.

1. *How can you prevent chemical changes that take place because of the oxygen in the air?*
2. *What are two ways of preventing chemical changes in food?*
3. *Name two chemical changes that are harmful. Explain why you think they are harmful.*

QUESTIONS TO ANSWER

1. Name two things in your schoolroom that have been made by a chemical change. Name one thing that your mother uses which is made by a chemical change.

2. Why are chemical changes important to us?

3. The picture on the left on this page shows the bubbles of gas in a cake that is baking. What two kinds of changes in materials do we use when we bake a cake? Explain your answer.

4. Long ago, people did not know about elements and compounds. Could they explain rusting, decaying, and the souring of milk?

5. Suppose you heated a material in a test tube and could not see any change in it. Would you then be sure that the material was an element?

6. Do you think that there are more compounds in the world than elements? Explain your answer.

7. When colored cloth is washed, it sometimes loses its color. What do you suppose has happened?

8. Tell something you have done to prevent a chemical change.

9. The picture on the right on this page shows some cattle that are feeding. Later, they will be used for meat. Explain how chemical changes help us get our meat supply.

10. You can buy flour that is all ready to use for making pancakes. The directions on the package tell you to keep it dry. Why do you think this is important?

11. When we put sugar into lemonade, do we make a chemical change?

THINGS TO DO

1. Find out more about elements. Which ones are the most common?

2. Read about some scientist who discovered one of the elements and make a report to your class.

3. Go to a store. Make a list of the things you find that have been made from other materials.

4. Find out what these materials are made from—gasoline, artificial rubber, perfumes, paint, kerosene, dyes for coloring.

5. Make a list of rules for safety in doing experiments. Put the list on the bulletin board.

6. Find out what elements and compounds are found in the air.

7. Put sugar and salt together. Do they make a compound? Or are they just mixed together? How do you know?

8. Is black soil a mixture of materials or just one compound? To answer this question, put about three inches of black soil in a tall glass. Fill the glass with water. Then cover the top and shake the glass until the soil and water are well mixed. Allow it to stand for several hours. What do you see in the glass?

★ In Unit Six You Will Learn ★

★ *What we need to make a fire* ★ *What fires need to keep them burning* ★
★ *What happens when things burn* ★ *How we can conserve our fuels* ★
★ *What we can do to prevent fires* ★ *How we can put out fires* ★

⋆ UNIT 6 ⋆

How Do We Control Fire?

One spring day, the Bates family was having a picnic in the woods. Betty helped her mother spread a big cloth on the grass near a little stream. Then they set the food from their picnic basket on the cloth.

"When do we eat?" asked Bill. "I'm hungry."

"So am I," said his father, "but those 'hot dogs' we brought won't taste good if they're cold. We'll have to cook them first. You can help me make a fire."

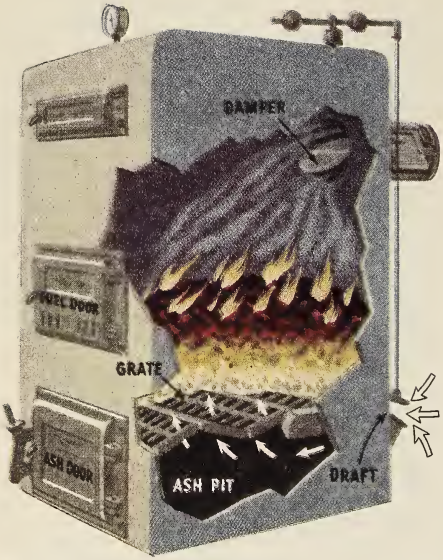
Bill thought it would be fun to cook outdoors. He ran off to get some twigs and branches. Soon he came back with his arms full. His father was getting a place ready for the fire. Bill and Betty watched him work.

"When we make a fire in the woods," he explained, "we must be sure that it will not spread. So first we find a spot away from bushes and trees, and we clear away the dead leaves and dry grass. Then we can start building the fire."

On the bare ground, Mr. Bates made a pile of little twigs. Then he put some bigger twigs and branches on top. The pile of twigs and branches looked somewhat like an Indian wigwam. "We put the little twigs on the bottom, because they catch fire more easily than the big ones do," he went on. "And we pile them up like this so that the air can get in and around them.

"Now we're ready to start the fire. The wind is coming from the east. So we will light the fire on that side. We always light a fire on the side toward the wind. Then the wind blows the flames up through the pile of twigs and branches."

He struck a match and lit the bottom twigs. When a good fire was burning, the Bates family cooked their "hot dogs" and then sat down to eat. They watched the fire burn down to a heap of ashes. After the meal, it was soon time for them to start home.



Mr. Bates' furnace looked very much like this. The firebox is the place where the fuel is burning.

"Before we leave," said Mr. Bates, "we must be sure the fire is out. Betty can help me cover the hot ashes with sand and dirt. Bill, you get a pail of water from the stream. We'll pour it over the ashes, too. Then we'll know they can't blaze up again and set the woods on fire."

By the time the family got home, it was much colder outdoors. "I shouldn't have let the fire in the furnace go out," said Mr. Bates. "Now I'll have to make another fire. This must be my day for making fires."

Betty and Bill watched their father start the fire in the furnace. He opened the top door and looked in. "I'll have to get some of these ashes out first," he said. He moved a handle back and forth, and the ashes fell into the space below. When the children looked into the furnace, they could see some iron bars moving.

"That is the grate," their father said. "As I move this handle, the bars move from side to side. Then the ashes can fall through the grate into the ash pit below. Do you see the holes in the grate? They let air come up from below."

Now Mr. Bates put some paper, some small pieces of wood, and a few larger pieces of wood on the grate bars. He also put a little coal on top. "I don't build a wigwam of sticks as I did in the woods," he said, "but I do lay the wood so that the air can get in and around it. Now let's look at the draft and the damper. I open this draft under the grate to let air in. Then I turn this damper in the pipe to let out smoke and gases from the fire."

He lit the paper. The small pieces of wood and then the larger pieces began to burn. At last, the coal caught fire. "Coal won't burn until it is very hot," he explained. "When the coal is burning well, I can put in some more. Then I can close the draft and the damper a little. If I leave them wide open, the coal will burn up too fast. And most of the heat will go up the chimney. That would waste a great deal of coal."

What do we need to make a fire?

YOU HAVE READ about making a fire in the woods and about making a fire in a furnace. Let us stop and think over what we must do to make a fire in either place. What do we need to start a fire?

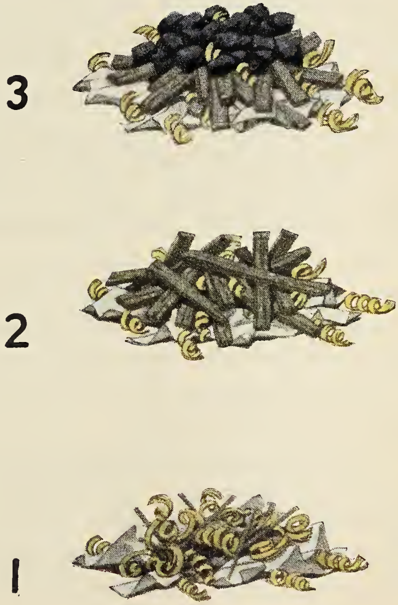
Of course, to make a fire, we must first have something that will burn. Some materials will burn, but others will not. You know that paper, cloth, wood, and coal will burn. So will oil and gas. But water, sand, iron, glass, stone, and brick will not burn. We cannot use them to make a fire. Materials that will burn are called *combustible* materials. So you see that the first thing we need for a fire is a combustible material.

Not every material that will burn catches fire easily. You cannot light a piece of coal with a match. To start a fire, we need a material that will catch fire easily. Paper, cloth, dry twigs, leaves or grass, wood shavings, and little sticks of wood are all materials that catch fire easily. We can use them to start a fire.

Materials that catch fire easily are those that need only a little heat to make them burst into flame. Every combustible material must be heated to a certain temperature before it will catch fire. Scientists call this the *kindling temperature.* If a material catches fire easily, we say that it has a low kindling temperature. A great deal of heat is needed to make coal catch fire. So coal has a high kindling temperature.

A burning match will light some paper or wood shavings. It gives enough heat to make them catch fire, because they have a low kindling temperature. Burning paper or shavings will make some sticks of wood hot enough to burst into flames. Then the heat from the blazing sticks will make a piece of coal catch fire.

When we make a fire, we put the materials that catch fire easily on the bottom. Above them, we put the materials that need a little more heat to



start them burning, and so on. When we light the materials on the bottom, they burst into flames. The heat from them passes up through the other materials and makes them hot enough to burn. Then they burst into flames.

So far, we have seen that there are two things we need to make a fire. First, we need to have a combustible material. Second, we need to have this material heated to its kindling temperature. There is still another thing that we need for making a fire. If you will think a minute, you will see what else is needed.

You remember that Mr. Bates piled the twigs for his fire in the shape of a wigwam so that air could get to them. When he was building the fire in the furnace, he opened the draft and shook the grate to let the ashes out. The air could then get into the firebox. To start a fire, there must be air near the combustible materials.

Now you know what we need to make a fire. So you can understand why we light fires the way we do. People had no matches until about 100 years ago. Indians started fires by whirling a hard, pointed stick against a soft piece of wood. As the stick rubbed on the wood, the friction produced heat. Materials with a very low kindling temperature, such as dry wood, leaves, or moss, were put around the rubbing surfaces. When they became hot enough, they burst into flames. You may think it would take a long time to start a fire in this way, but it has been done in about six seconds! The boy in the picture is making a fire in this way.

Another way of starting a fire by friction was used a long time ago. A piece of flint and a piece of steel were struck together to make sparks. The sparks fell on bits of dry, decayed wood or scorched linen, called *tinder*. Tinder catches fire easily. Even today we use friction to start fires. In friction gas lighters and cigar lighters, a steel wheel turns against a piece of flint to make sparks. The sparks fall on a wick soaked in a liquid that catches fire easily.

Matches that would light when their tips were rubbed on something were invented only about 100 years ago. The tips are made of materials that can be set on fire easily. Rubbing them on a rough surface makes the tips hot enough to burst into flames. Matches have been greatly improved since they were first invented. Safety matches will not light when they are rubbed on just any rough surface. They must be struck on a specially prepared surface. They are less likely to be lit by accident. Some matches are made so that the tips will not fly off when they are struck, and the matchsticks will not glow after the flame is out. Matches help us, but they must be used very carefully.

Safety rules for using matches

1. Never leave matches where rats or mice can get at them. Rats or mice have started fires by chewing on matches.
2. Never carry loose matches in your pocket. If the matches are in a cardboard folder, keep the folder closed.
3. Before lighting a match from a folder, close the folder. Sparks from the match may set the other matches on fire.
4. Be sure that the match is completely burned out and is cold before you throw it away.

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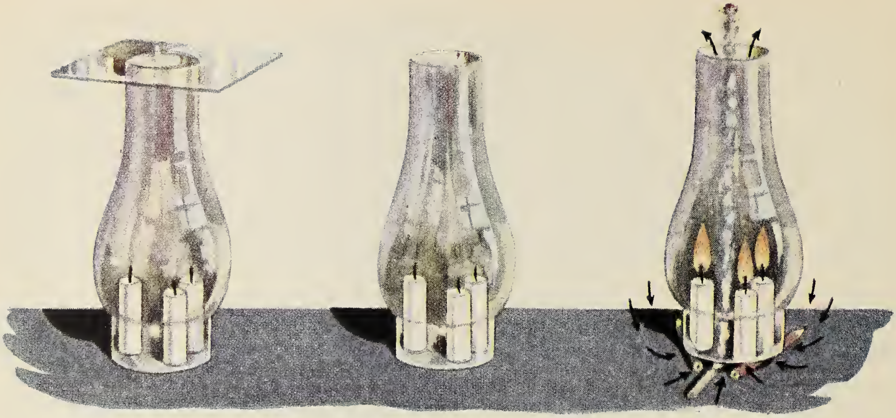
1. *What is a* combustible *material? Name some materials that are combustible.*
2. *Why do we use matches to light a fire?*
3. *What does* kindling temperature *mean?*
4. *Which of these materials have a low kindling temperature?*
   Paper *Gasoline* *Hard coal* *Leaves* *Large stick of wood*
   Wood shavings *Cloth*
5. *What are the different ways that have been used to start fires? Which way is easiest?*



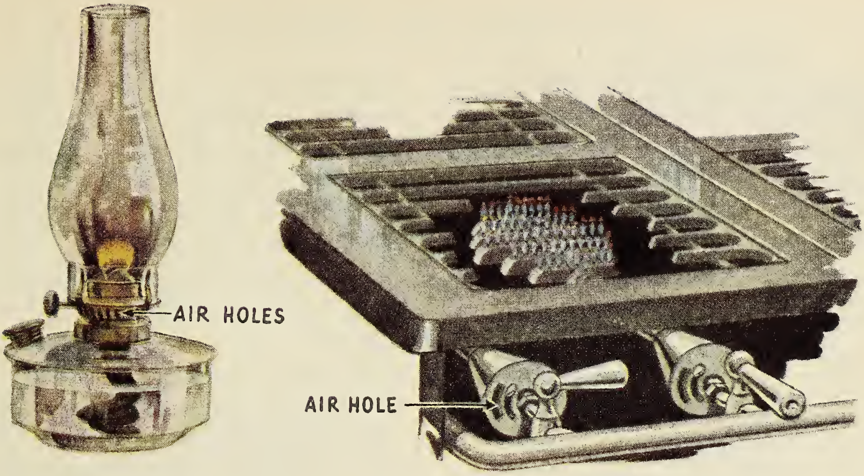
What do fires need to keep them burning?

To answer this question, let us first do an experiment. Get three small candles, each about two inches high. Set them on a piece of glass and light them. Put a lamp chimney over them and cover the top of the chimney with another piece of glass. What happens? Do you think the candles will burn if you leave the top of the chimney open? Light the candles again and set the chimney over them without the glass. What happens this time?

Now put a few short pencils or other sticks around the candles. Light the candles again and set the chimney on the pencils. As you can see, the candles keep on burning. Light a splinter of wood or a small roll of paper. Let it burn for a moment and then blow out the flame. Hold the smoking splinter at the bottom of the chimney. Where does the smoke go? Now let us see what the experiment showed.

The candles kept on burning only when air could get in at the bottom of the chimney and out at the top. This means that a current of fresh air must be kept moving past the flames.

You know how this current of air is made. The burning candles heat the air in the chimney. When air is heated, it expands and gets lighter. The air outside the chimney is colder than the air inside. This colder air is heavier than the hotter air inside. Gravity pulls down on the colder air with more force. This heavier, colder air goes under the chimney and pushes the lighter, hotter air up. The same thing happens with a fire outdoors or in a furnace or stove.



Look at the pictures on this page. The picture on the left shows how fresh air gets into a kerosene lamp. The air gets to the flame through the holes below the chimney.

The other picture shows how a burner in a gas stove is supplied with gas and air. Gas comes into the burner through the pipe along the front of the stove. Air enters through the air holes and mixes with the gas. So when the gas is lighted, it has oxygen to keep it burning. Now let us see what we need to start a fire and keep it going.

1. We need a combustible material.
2. We need to heat the combustible material to its kindling temperature.
3. We need a material with a low kindling temperature to start a fire easily.
4. We need to arrange the fire so that it can get a current of fresh air.

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1. *What things are needed to make a fire?*
2. *Tell how you would arrange materials to make a fire. Give reasons for what you would do.*
3. *Why must ashes be taken out of a furnace or stove?*
4. *Does a fire help keep itself burning? Explain your answer.*
5. *A pile of wood shavings burns more easily than a pile of sawdust. Explain why this is true.*
6. *Why is it hard to burn a thick magazine? What is the best way to do this?*

What happens when things burn?

WITHOUT FIRE, our lives would be very different and much less comfortable. We use fire to keep our homes and other buildings warm, to cook our food, and to supply hot water for washing. Fire changes water to steam that can make our machines move. And it burns gasoline in a gasoline engine or oil in a Diesel engine. Fire helps us to use the energy stored in materials to do our work, to keep us warm, and even to give us light.

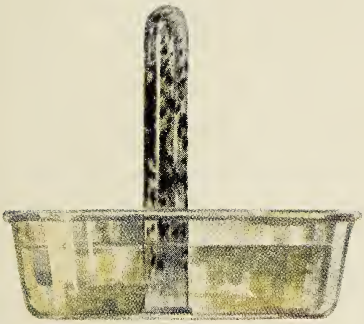
As you know, any material that we burn to get heat or light is called a fuel. We have solid fuels, such as wood, coal, and coke. Coke is made by heating coal. We have liquid fuels, such as oil, gasoline, kerosene, and alcohol. And there are several kinds of gas fuels. Your home may be heated with wood, coal, coke, oil, or gas. In the kitchen, your mother may use gas, kerosene, gasoline, coal, wood, or electricity to cook your meals. If you live in the country, you may use kerosene lamps or gasoline lamps to give you light. In some ways, all fuels burn alike. So let us find out what happens when any kind of fuel burns.

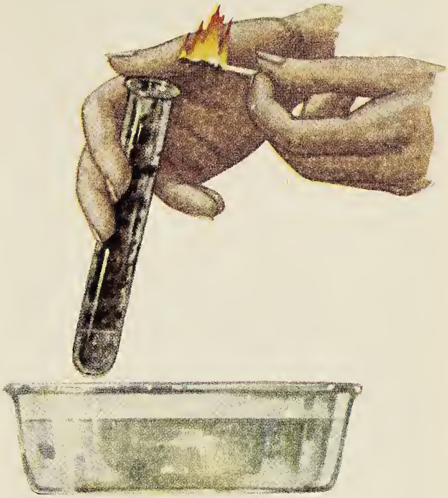
When anything burns, it gives off something you can feel. If you have ever put your hand near a fire, you know what it is. It is heat. Every fire gives off heat. No matter what kind of fuel is used, it gives off heat when it burns. And it usually gives off something you can see, too. A flame gives off light. Wood, coal, oil, gas, kerosene, and gasoline all burn with a flame. But the color of the flame is not the same for every fuel. Coke does not burn with a flame like most fuels, but it does glow and give off light.

You must have noticed something else when a thing burns. It gets smaller and smaller. Liquid fuels, such as oil, kerosene, or gasoline, and gas fuels disappear completely when they burn. Solid fuels, such as wood and coal, always contain some materials that will not burn. These materials are left as ashes.

Sometimes, but not always, smoke is given off when a thing burns. This happens when there is not enough fresh air. Unless a fuel gets plenty of air, it cannot burn freely. Smoke shows that part of the fuel is not being completely burned. For smoke is mostly tiny bits of fuel that are carried up by currents of air from the fire.

Besides the things you can feel and see, other things are happening when a fuel burns. Scientists know what these things are, and they can explain them. You already know that a chemical change takes place when any material burns. When a piece of hard, black coal has burned, only a few gray





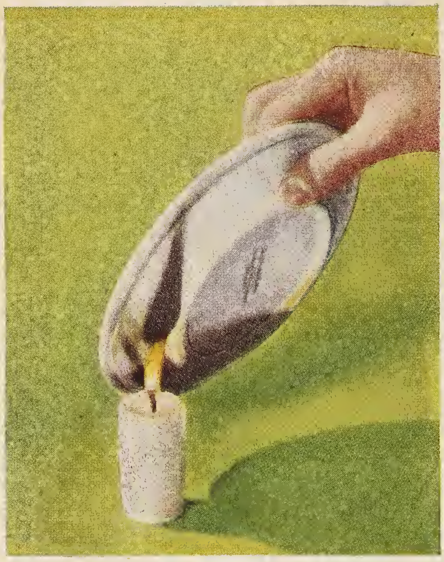
ashes are left. You can easily see that a chemical change has taken place, because ashes are very different from coal.

The experiment showed that a current of fresh air is needed to keep a material burning. As you probably know, air is not just one gas. It is a mixture of gases. About four fifths of the air is nitrogen, and one fifth is oxygen. It also contains carbon dioxide, water vapor, and a very small amount of a few other gases.

Perhaps you have wondered if all the parts of the air are used in burning or just one part of it. Does a burning material need nitrogen to keep it burning? Or does it need oxygen or some other gas in the air?

One way to find out is to take the oxygen out of some air and then see if materials will burn in the air after the oxygen has been taken out. There are several different ways of doing this. One of the easiest ways of taking oxygen out of the air is to let iron rust in the air. You remember that when iron rusts, it changes to a soft, crumbly material because it combines with oxygen. A chemical change takes place. From the iron and the oxygen, a new material is made.

Fill a test tube or a small bottle with water and then pour the water out. The inside of the test tube will stay wet with water that sticks to it. Now put some iron filings into the test tube and shake it. The filings will stick to the wet sides of the tube. Set the test tube with its mouth down in a pan of water and leave it there for several days. Look at the test



tube from time to time but do not take it out of the water.

The dark-gray filings change to a brownish color as they rust. This shows you that the iron has rusted. When iron rusts, it takes oxygen from the air. If you look carefully, you can see that water rises in the test tube and takes the place of the oxygen. After a few days, all the oxygen in the test tube has combined with the iron filings. You can use the test tube to find out if materials will burn in air that has no oxygen in it.

Put your thumb over the mouth of the tube under water. Take the tube out and turn it right side up. Keep your thumb over the mouth. Now light a match. Then quickly take your thumb off the test tube and put the burning match down into it. What happens? This experiment and others all show the same thing. No material will burn unless there is oxygen to combine with it. All materials combine with oxygen when they burn.

Now do an experiment to see what happens when a paraffin candle burns. Paraffin is a compound made of two elements, carbon and hydrogen. Light the wick of the candle. When the candle is burning well, blow it out. Notice the white smoke that is given off for a short time afterward. Light the candle again and then blow it out when it is burning well. Hold a burning match in the white smoke about half an inch above the top of the wick. What happens?

As the candle burns, the paraffin changes to a liquid. Most of this liquid gets hot enough to change to a gas, but some of it does not. You can see this liquid running down the sides of the candle. When the candle has been blown out, the white smoke contains tiny bits of paraffin. If you hold a burning match close to the wick, the paraffin in the smoke will burn and light the candle again.

The gas contains the same two elements as paraffin. They are carbon and hydrogen. You can see that the gas contains carbon if you hold a cold plate in the candle flame. This cools the carbon so that it does not burn. You can see the black, unburned carbon on the plate.

When carbon burns, it joins with oxygen to form a compound called carbon dioxide. You have already heard of carbon dioxide. It is a colorless gas. When you breathe out, it is given off from your lungs. You can do an experiment to find out if carbon dioxide is formed when a candle burns.

You will need some *limewater* for the experiment. Limewater is a clear liquid that turns milky when carbon dioxide is put into it. Pour some clear limewater into a glass. Use a piece of glass tubing or a soda straw to blow air into it for about two minutes. Does the limewater turn milky? Then there is carbon dioxide in the air you breathe out.

Now fasten a piece of wire around the candle and light it. Then lower it into a glass jar. Cover the jar with a flat piece of glass. When the candle goes out, slide the cover a little to one side and pull the candle out. Then quickly pour some clear limewater into the jar. Cover the jar and shake it. What happens to the limewater? What makes it do this?

Carbon dioxide was formed in the jar when the candle burned. Carbon in the gas combined with oxygen in the air. Of course, there was a little bit of carbon dioxide in the jar before the candle burned. Air contains some carbon dioxide. But there was much more carbon dioxide after the candle burned. You can easily see this for yourself. Pour some clear limewater into another jar and shake it. Look at the limewater in this jar and in the other jar where the candle burned. What difference do you notice? Which jar has more carbon dioxide in it?

Now you can do another experiment to find out what happens to the hydrogen when the candle burns. Light the candle and put the mouth of a cold glass jar down over it. Be sure that the glass jar is thoroughly dry. Hold it so that the burning candle can get air. Now look at the inside of the jar. Do you see moisture sticking to the sides? This moisture is water. When hydrogen combines with oxygen, water is formed. Water, as you know, is a compound made of hydrogen and oxygen.

From what you have learned about a burning candle, you can understand why it disappears as it burns. The carbon in the paraffin combines with oxygen to form carbon dioxide. As you know, carbon dioxide is a colorless gas. It quickly mixes with the air. The hydrogen in the paraffin combines with oxygen to form water. The water is in the form of water vapor, which is also colorless. And it also mixes with the air. A burning candle disappears because it joins with oxygen to form colorless gases.

Nearly all the fuels we use contain hydrogen and carbon. When these fuels burn, they first change into a gas that contains carbon and hydrogen just as the candle did. Then this gas burns and forms carbon dioxide and water vapor. As these fuels burn, they get smaller or disappear completely. The materials that do not combine with oxygen are left as ashes.

1. *How can you tell when a material is burning?*
2. *Tell what you did to show that a material must have oxygen when it burns.*
3. *How did you tell that carbon changes to carbon dioxide when it burns?*
4. *How did you tell that hydrogen changes to water vapor when it burns?*
5. *Why do some fuels disappear completely when they burn? Name some fuels that do this.*
6. *What are ashes? Name some fuels that leave ashes when they burn.*

How can we conserve our fuels?

DID YOU EVER see black smoke pouring out of a chimney? The smoke is mostly tiny bits of unburned carbon. In a big city where many homes, factories, and railroads burn fuel, smoke is often a nuisance. The air is full of smoke. People breathe it into their lungs, and it is bad for them.

Tiny bits of carbon settle as greasy, black soot on clothing, furniture, buildings, and streets. Then people must spend much time and money to get things clean again. On a calm day, smoke sometimes gathers in a thick cloud over the city. It cuts off much of the sunlight. Electric lights must be turned on. That uses more of our fuel, too.

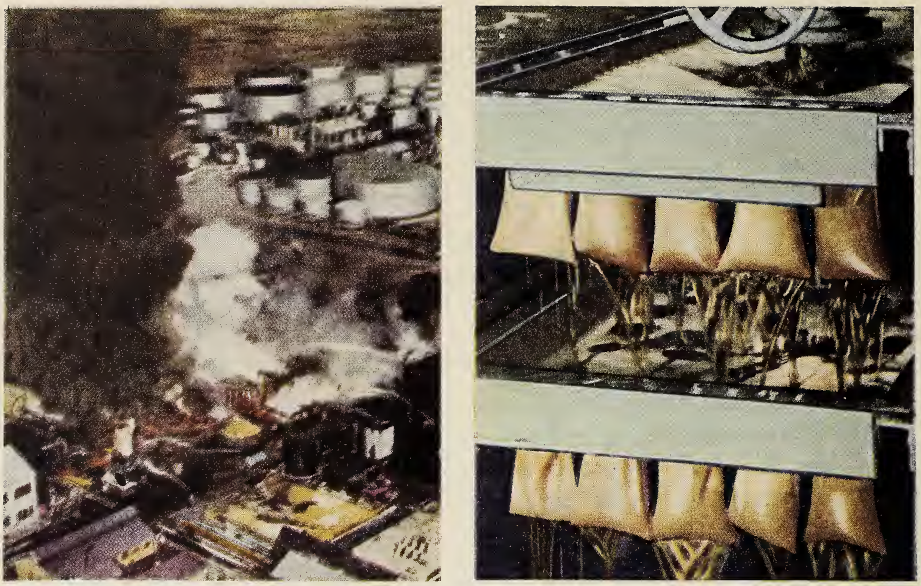
But smoke is more than a nuisance. It is a waste of valuable fuel. We get no heat from fuel that goes up in smoke. So we have to use more fuel to get the heat we need. Whenever you see black smoke coming out of a chimney, you can tell that fuel is being wasted. Do you know why fuel is so valuable that we must not waste it? Of course, fuel costs money. When we buy fuel, we want heat and not smoke. Yet there is another important reason why we must save fuel.

Our common fuels are wood, coal, coke, oil, gasoline, kerosene, and gas. As you know, coke is made by heating coal. Gasoline and kerosene come from oil. We get gas from the earth and also from coal and oil. Every year we use more and more fuel. But in all the world only one of our common fuels is now being replaced. That is wood. The coal, oil, and gas we take from the earth were made millions of years ago. When they are gone, there will be no more.

Scientists think that our supply of coal will last at least 100 years. Our supplies of oil and gas may not last so long if we keep on using them up as fast as we do now. Just how long our supplies of coal, oil, and gas will really last depends on how carefully we use them. If they are wasted, they will be gone much sooner than if we use them carefully. That is why we must conserve our fuels.

One thing we can do is to keep fires from smoking. There are only two reasons why a fire smokes. Either the fuel does not get enough oxygen, or some of it is not hot enough to catch fire. You have probably seen smoke coming out of the pipe behind an automobile. The smoke shows that not enough air has been mixed with the gasoline or that the mixture is not hot enough to burn completely.

A kerosene lamp or stove will smoke if the wick is turned too high. There is not enough oxygen near the wick to burn the kerosene. If gas or oil burns with a smoky, yellow flame, not enough air is being mixed with the fuel. Tiny bits of hot carbon make the flame yellow. If coal is burned in a furnace or stove, we can open the draft wider to get more oxy-



Lightning started this fire in which thousands of gallons of valuable oil are being wasted. The picture on the right shows how one big company is saving oil. The oil is put through cloth bags to remove the dirt. Then the oil can be used again.

gen to the fire. Or we can take some ashes out of the grate and the ash pit. Air can then get to the coal.

Too much coal should not be put on a fire at one time. Before any fuel will burn, it must be hot enough to catch fire. You saw carbon collect on a cold plate held in a candle flame. The carbon was not hot enough to burn. The same thing happens when too much coal is put on a fire. Some of it does not get hot enough to catch fire. Then unburned carbon and gases go up in smoke. This often happens when a coal fire is started.

We can conserve much coal if we learn to use it properly. To get the most heat and the least smoke from coal, we should put only a little coal on a fire at one time. We will have to put coal on more often, but most of it will burn. Very little coal will go up the chimney as black smoke, as it is doing in the chimneys in the picture on page 161.

An *automatic stoker* is a machine that makes it easy to conserve coal. This machine supplies just the right amount of coal to a fire all the time. A stoker can be connected to a furnace in a home. Or it can be used with a boiler in a big building, a factory, or a locomotive like the one in the picture on page 60.

Heat will not easily go through some kinds of materials. Putting blocks of material like this inside the roof and walls of a house is one way to keep heat from being wasted.

Another thing we can do to conserve our fuels is to save heat. Much of the heat we get from fuels is wasted. Heat goes out through the roof, walls, and windows of our buildings. There are several ways to cut down this loss of heat. We can fill cracks so that hot air cannot get out and cold air cannot get in. We can put special materials in the walls and roof to keep heat in. And we can use double glass in the windows.

A great deal of heat is wasted in cooking. When an oven door is open, heat is lost. It also goes out through the sides and top of the oven. When a small pan is set over a large burner on a stove, heat is wasted around the sides of the pan. More heat from the burners is lost when food is cooked in uncovered pans. But the biggest loss of heat probably comes from using a hotter fire than is really needed to cook the food.

Scientists have made discoveries that help us conserve our fuels. Better stoves, furnaces, and boilers have been invented to give more heat and use less fuel. Steam engines, gasoline engines, and Diesel engines have been greatly improved. They now make better use of the energy stored in the fuels that we need.

No matter how carefully we use our supplies of coal, oil, and gas, there is still no way to put more of them back in the earth. So we must find other ways to conserve the supplies we now have. One way is to use fuels made from plants whenever we can. Wood is a common fuel where it is cheap and plentiful. Gas and alcohol can be made by heating wood. Alcohol can also be made from grain. But most of these plant fuels cost more to use than coal, oil, or gas that we take from the earth.

Still another way to conserve fuels is to make more use of other sources of energy. Moving water is used to turn machines that produce electric current. In many parts of our country where electric current is cheap, it is now being used to cook food and heat water. Moving air can also be used to produce electric current. But unless the wind is blowing, no electric current is produced.

For many years, scientists have been trying to find ways to use the huge amounts of heat we get from the sun. So far, they have not found a really good way to do this. A few homes have been built so that on clear days the sun helps heat them. Some day scientists may learn how to use the energy stored in all materials. Until they do this, we must conserve the supplies of coal, oil, and gas that are now in the earth.

1. *Why must we conserve our supplies of coal, oil, and gas?*
2. *Give as many ways to conserve fuel as you can. Tell how each way helps save fuel.*
3. *Is fuel being wasted in your community? How do you know?*
4. *If cooking pans become very black on the outside every time they are used on a gas stove, what should be done? Why?*

What can we do to prevent fires?

NO ONE KNOWS when fire was first used or who discovered how to use it. We do know that it was one of the greatest discoveries ever made. When fire is under control, it keeps us warm and helps do our work. But something very different happens when fire gets out of control. Buildings and forests are destroyed. People and animals are burned. Every year, fires do great damage.

Almost all of these fires are accidents. But accidents do not just happen. They are caused by people who

This forest ranger cleared the grass away before he built his fire. Now he is putting the fire out before he leaves. What two things will he do to make sure that the fire is out?

are careless. Once a fire gets started, it is often hard to put out. So the best way to keep fires from doing damage is to keep them from starting at all.

To start burning, every fire must have three things—a combustible material, enough heat to raise the material to its kindling temperature, and a supply of oxygen. If any one of these three things is missing, a fire cannot start. To prevent fires, we can use what we know about starting fires.

In our homes and other buildings, *fireproof* materials can be used in many places. The materials that will burn should not be put near heat that might set them on fire. Liquids or gases that catch fire very easily should be put into airtight, fireproof containers and kept away from heat.

We can prevent many fires by being careful with matches. People light matches and throw them away before they are out. If they fall on something that will burn, a bad fire may start. Matches should always be kept in a safe place where they cannot start a fire by accident. They should never be left where little children can play with them.

You already know why we must be careful with fires outdoors. An open fire can easily spread to other things if it is not made properly. Leaves, grass, and twigs should be cleared away from the ground where the fire

Do you think this a safe place to keep old rags? Why?

is made. The fire must be kept away from trees, bushes, or anything else that may spread it.

A small fire is safer than a big one. If a fire is too big, it makes a strong current of air move toward the flames and then upward. This current of air may carry sparks and other bits of burning material to grass, trees, or buildings nearby. The same thing can happen on a windy day with even a small fire.

Many parks have fireplaces where you can cook your meals. It is safest to use one of these fireplaces if you want to cook outdoors. But any outdoor fire should be watched all the time. Be sure to put it out with water, sand, or dirt before leaving it.

Sometimes people start fires with kerosene or gasoline. This is a very dangerous thing to do. Only a little heat will set kerosene and gasoline on fire, because they quickly change from a liquid to a gas. If much of this gas catches fire at one time, it may explode. The explosion will scatter burning materials from the fire. This is bad enough with an outdoor fire, but it is far worse with a fire that is being made indoors. Never use kerosene or gasoline to start a fire.

Fires are sometimes started by oily rags that have been wadded up or thrown in a pile. What happens is this. Oxygen slowly combines with the oil. A little heat is produced. The rags get warm. Because the rags are in a wad or pile, all the heat cannot get out. The rags get warmer and warmer. At last, some of the oil changes to a gas. The rags are hot enough to set the gas on fire. It bursts into flames and sets the rags on fire, too. Oily rags should be spread out, hung on a line, or kept in a covered metal container.

There are many ways in which fires can start. Kerosene or gasoline lamps fall on the floor or set fire to curtains. Wooden boxes catch fire when hot ashes are put in them. Electric wiring gets hot enough to start something burning. Hot cooking fats blaze up on a stove. Liquids used for clean-ing, such as naphtha and gasoline, catch fire from friction. But no matter how the fire starts, the real cause is usually this. Someone was careless.

Safety rules for preventing fires

1. Be careful with matches. Put them out before you throw them away. Use safety matches if possible. Keep large kitchen matches in a covered metal box.
2. Keep an outdoor fire from spreading. Build a small fire. Make it on bare ground in a place where the wind will not blow it toward anything that may catch fire.
3. Before you leave an outdoor fire, put it out. Pour water on it or cover it with sand or dirt.
4. Never use kerosene or gasoline to help start a fire. Use paper and small bits of wood.
5. Do not set kerosene lamps or gasoline lamps where they can fall on the floor or set fire to curtains. Put them near the centre of a table and away from windows.
6. Do not leave oily rags wadded up or thrown in a pile. Spread them out, hang them up on a line, or keep them in a covered metal container.
7. Put ashes in metal containers instead of wooden boxes.
8. Do not use worn or broken electric cords.
9. Replace a "blown" electric fuse with another of the right size.
10. Do not play with firecrackers or any kind of fireworks.
11. Be careful about using flour and cornstarch over an open flame, such as on a gas stove. They may start a fire or explode.
12. Be careful with hot cooking fats on a stove. They easily blaze up and spread fire.
13. Do not use naphtha or gasoline to clean clothes indoors. It is dangerous even to use them outdoors.

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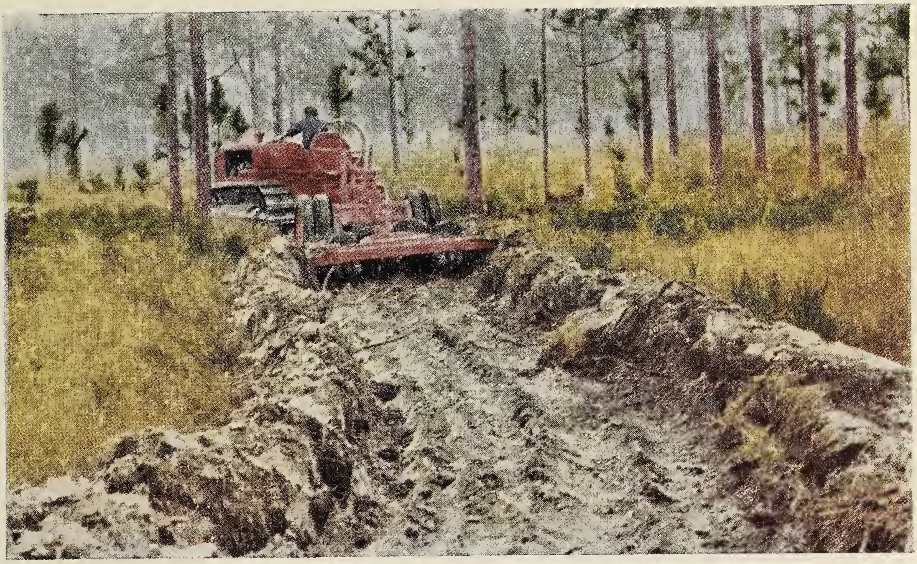
1. *What is the best way to keep fires from doing damage?*
2. *Tell how you can use what you know about burning to prevent fires.*
3. *Give a reason for each of the first six safety rules for preventing fires.*
4. *What is usually the cause of a harmful fire? Explain your answer.*
5. *Have there been any fires that caused much damage in your community? How did they start?*

How can we put out fires?

WHAT SHOULD YOU DO if you see a fire start? The first thing to do is tell a grown-up. If you cannot find one, report the fire at once to the fire department. You should know what telephone number to call. Find out if you do not know. Even if you do not know what number to call, you can ask the telephone operator to report the fire. But this usually takes more time. And the sooner the fire is reported, the quicker the fire department can get there to put it out.

If you live in a city, you will probably find a fire-alarm box every few blocks. There are different kinds of fire-alarm boxes. One kind is kept locked, and the key is at the nearest house or store. In another kind, you open a small door on the front of the box, pull a lever down all the way, and then let it go. Still another kind has a glass door you must break to pull the lever. When the lever is pulled, a signal sounds in the central fire station. Then an alarm is sent to the fire station that is nearest the fire-alarm box.

Always stay near the box until the fire engine arrives, so that you can tell the firemen exactly where the fire is. If you ever have to report a fire, you will be in a hurry. So be sure to find out ahead of time how to work the fire-alarm boxes in your city. Never report a fire unless there really



This man is cutting a fire lane. If the grass catches fire on one side of the lane, the fire will probably not jump across the bare lane.

is one. If a fire engine comes to answer a false alarm, it may be too late to get to a real fire somewhere else. Then the real fire might get such a big start that many buildings would be burned.

You already know what things a fire needs to burn. So you can probably tell three things we can do to put out a fire. One thing we can do is to clear away from the fire any material that will burn. This will keep the fire from spreading. Another thing we can do is to cool the burning material so that it is no longer hot enough to burn. The third thing we can do is to shut off the supply of oxygen. Let us see how these things are actually done.

In the forest, *fire lanes* are usually made. A fire lane is a wide path from which all trees and bushes have been cut away. Sometimes it is plowed to cover the grass and leaves with soil. A fire lane is one way of clearing away materials that will burn. When a fire starts in the forest, it may keep on burning until it gets to the fire lane. Unless the wind is strong, the fire usually cannot jump across the fire lane.

A grass fire can sometimes be stopped by making a *backfire.* To do this, the grass is set on fire some distance ahead of the main fire. The backfire is kept under control. It makes a wide burned space in the

Can you tell why great clouds of smoke pour out when water is put on a fire?

grass. When the main fire gets to the burned space, it usually stops because there are no materials left to burn.

Sometimes a large fire in a big city gets completely out of control. The fire is so hot that firemen cannot go near it. To keep the fire from spreading, the firemen may blow up buildings in the path of the fire. The buildings fall into a heap, covering up the materials that will burn easily. When the fire gets to them, there is not much left to catch fire. The firemen have removed the material that will burn from the path of the fire.

Of course, the commonest way to put out a fire is to throw water on it. The water does two things to put the fire out. It covers the burning materials and shuts off the supply of oxygen. It also cools the burning materials so that they are no longer hot enough to burn. Small fires are easily put out with water. To put out large fires, like the one shown in the picture on this page, thousands of gallons of water must be used.

But a stream of water will not put out some kinds of fires. Sometimes hot cooking fats blaze up on a stove. If water is poured on the blazing fat, it will just spread the fire. Do you know why this happens? The cooking fat is lighter than water. So it floats on top of the water. Then the water cannot shut off the supply of oxygen. As the water spreads, the blazing fat spreads, too. Never pour water on blazing fat. Throw baking soda on it or put a metal cover over it.

When kerosene, gasoline, or oil catch fire, they act like blazing fat. A stream of water only makes them spread. They are lighter than water, and they float on top of it. The water does not shut off the supply of oxygen. But firemen sometimes use a fine spray of water to put out a kerosene, gasoline, or oil fire. The fine spray cools the burning materials until they are no longer hot enough to burn. And it does not spread the fire as a stream of water would.

Another way to put out a fire of kerosene, gasoline, or oil is to throw sand or dirt on it. This shuts off the supply of oxygen. It also cools the burning material.

A third way is to use a fire extinguisher that contains *carbon tetrachloride*. This is a liquid that changes to a gas when it gets hot. The gas is about five times as heavy as air. It settles on the fire, covers the burning material, and shuts off the oxygen. Many people carry this kind of fire extinguisher in their automobiles. It can be used on most kinds of fires.

You should know how different kinds of fire extinguishers work. Can you tell why this is true?

IN CASE OF FIRE KNOW YOUR FIRE EXTINGUISHERS
FIRST FEW SECONDS COUNT
CARBON DIOXIDE
PULL OUT THE PIN
TURN WHEEL TO LEFT
CARBON TETRACHLORIDE
★ TO OPERATE STAND AS NEAR AS POSSIBLE TO FIRE
TURN WHEEL TO LEFT
TAKE HOLD OF NOZZLE PRESS
USE ON ELECTRIC MOTORS & ELECTRICAL FIRES
"ALWAYS DIRECT THE
FOR MAGNESIUM FI
SODA ACID
TO OPERATE TURN UPSIDE DOWN
OF FIRE"
FOAMITE
TO OPERATE TURN UPSIDE DOWN
USE ON GASOLINE GREASE FIRES
DIRECT DISCHARGE AGAINST SIDE OF TANK
ALWAYS TRY TO OBTAIN A BLANKET OF FOAM ON FIRE
TAKE HOLD OF NOZZLE

In your school, there is probably another kind of fire extinguisher. It makes carbon-dioxide gas. You can do a simple experiment to see how carbon-dioxide gas puts out a fire. Put a teaspoonful of baking soda in a glass and pour some vinegar on it. Then hold a lighted match in the glass. What happens? A chemical change made carbon-dioxide gas from the baking soda and vinegar. The carbon-dioxide gas shut off the supply of oxygen from the lighted match, and the match could no longer burn.

When a carbon-dioxide fire extinguisher is turned upside down, an acid mixes with another material dissolved in water. A chemical change takes place, and carbon-dioxide gas is formed. The gas rushes out of the extinguisher and forces the water out, too. Carbon dioxide is heavier than air. It settles on the fire and helps shut off the oxygen. The water also helps shut off the oxygen, and it cools the burning material. Because of the stream of water, this kind of fire extinguisher cannot be used to put out blazing kerosene, gasoline, grease, or oil.

The picture on this page shows a special kind of fire truck that is often used to put out very hot gasoline fires. The truck carries carbon-dioxide gas that is kept at a very low temperature. When the carbon dioxide comes out of the truck, it is like snow. It is cold and heavy, and it rapidly cools the burning gasoline below its kindling temperature. At the same time, another material that smothers the fire comes from the truck. This material and the carbon-dioxide snow together can put out a big gasoline fire in less than a minute!

Do you know what to do if your clothes catch fire? The worst thing to do is to run. This fans the flames. It brings more oxygen to the burning clothes and makes them burn even faster. If your clothes catch fire, stand still. Look around for a coat, blanket, rug, or anything like it. Lie down on this covering and roll yourself up in it as tightly as you can. This will shut off the supply of oxygen.

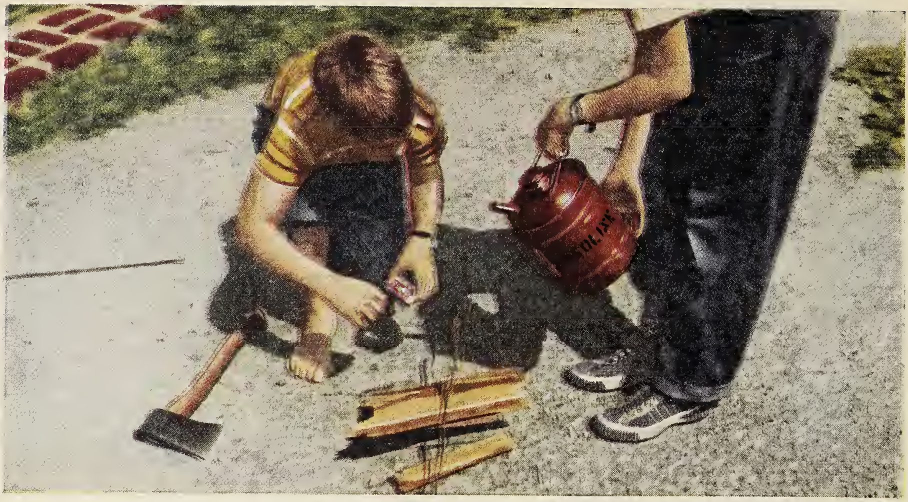
If another person's clothes catch fire, wrap a covering tightly around him. If you can find nothing to wrap around burning clothes, the best thing to do is to lie down and roll over slowly. At the same time, beat out the flames with your hands.

Safety rules for putting out fires

1. If you see a fire start, tell a grown-up or report it to the fire department at once.
2. Find out what telephone number you should call to report a fire.
3. Find out where the nearest fire-alarm box is and how it works.
4. After you report a fire from a fire-alarm box, stay near the box until the fire engine comes. Then tell the firemen exactly where the fire is.
5. Never report a fire unless there really is one.
6. Use water, sand, or dirt to put out small fires.
7. Never pour water on blazing fat. Throw baking soda on it or put a metal cover over it.
8. Never use a stream of water to put out a fire of kerosene, gasoline, or oil. Use sand, dirt, or a fine spray of water.
9. Learn how the fire extinguishers in your school work.
10. If your clothes catch fire, do not run. Lie down and roll up tightly in some covering. Or roll over slowly and beat out the flames with your hands. If another person's clothes catch fire, wrap a covering tightly around him.

---

1. *What three things can we do to put out a fire?*
2. *How does water put out a fire?*
3. *Why should a stream of water not be used on some kinds of fires? Tell how we can put out these fires.*
4. *What should you do if your clothes catch fire?*
5. *Tell what you would do if a fire started in your home.*



Are these boys acting safely? What safety rules should they remember?

QUESTIONS TO ANSWER

1. Why should the wood in a fire be loosely piled to burn well?

2. When a fire is started in a furnace or stove, what should be done to the draft and the damper? Explain your answer.

3. If a kerosene lamp smokes, what can you do to make it stop smoking? Tell why this will do it.

4. Explain why there are no ashes from a gas stove or a kerosene stove.

5. A piece of paper burns faster when it is held in the air than when it lies flat on the ground. Why does this happen?

6. Why does a pile of burning leaves give off much smoke when more leaves are thrown on the fire?

7. Kerosene or gasoline should never be put in a lamp that is hot. Explain why.

8. One kind of fire extinguisher makes a sticky foam. How do you think this helps put out a fire?

9. Give a reason for each of the ten safety rules for putting out fires that are given on page 173.

10. How could you do an experiment to discover whether soft coal has a lower kindling temperature than hard coal?

11. How should the draft and the damper on a furnace be arranged to get a hot fire?

12. What can you do to help conserve our supplies of coal, oil, gas, and wood? Explain your answer.

13. Why do you think we have chimneys in our homes?

14. If a fire started where there were no extinguishers, what are the things you might do?

THINGS TO DO

1. Make a drawing of a furnace or stove. Explain how the supply of oxygen is controlled.

2. Visit a fire station near your home or school. Find out what kinds of fire extinguishers the firemen use.

3. Cut out newspaper stories about fires and make a collection. List the different causes of fires reported in the newspapers.

4. Find out what kinds of roofing materials will not burn. Why are they better than wooden shingles?

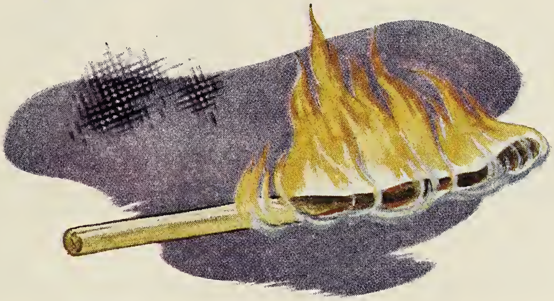
5. With your teacher watching you, light different kinds of matches to see how they start burning and how they keep on burning.

6. Find out what kinds of fuels are used in your community and what is being done to conserve them.

7. What can you and the other members of your class do to prevent fires in your community? Perhaps your teacher can get a fireman to talk to your class about preventing fires.

8. Look around your home for things that may start a fire or spread the fire after it has started. Make a list of the things you find and tell what you can do about them.

9. Find out how fires are sometimes started by *spontaneous combustion.* What kinds of materials may catch fire in this way?



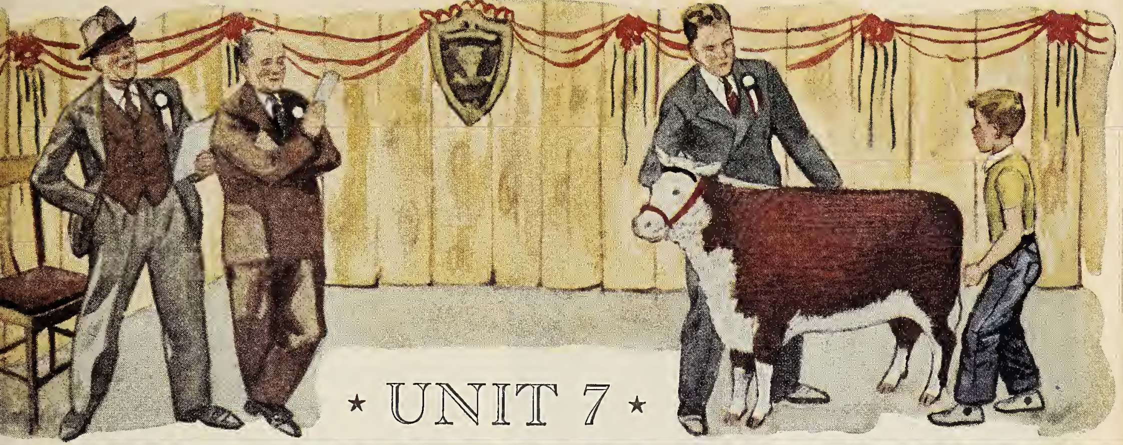
★ *In Unit Seven You Will Learn* ★

★ *What food does for you* ★ *What foods keep you warm and give you energy* ★

★ *What foods help you grow and keep healthy* ★

★ *How vitamins help you keep well* ★ *What water does for your body* ★

★ *What habits help you get the proper foods* ★ *What cooking does for your food* ★



★ UNIT 7 ★

Why Do You Need Food?

Bill was very excited when he came to school one morning in the spring. "My father gave me a sheep to raise all by myself," he told his friends. "I'm going to try to win a prize with it in the 4-H Club show at the local fair next fall."

Bill's school was in the country, and many of the children belonged to a 4-H Club. Members of the Calf Club were raising calves for the show. Jim was raising a pig for the Swine Club, while Nancy was raising chickens for the Poultry Club. They started to talk about what they had to do to get their animals ready for the show.

"What do you think is the most important thing you do for your animals?" the teacher asked the class.

Almost everyone answered, "Feed them so that they will grow big."

"They must grow strong, too," said Jim. "Animals that weigh a lot need strong bones to hold them up."

"Sheep must be fed so that they will have good wool," said Bill.

"Horses must have food to make them strong enough to pull big loads. The right kind of food makes them strong and also makes their coats smooth and shiny," Mary said.

"Chickens must be fed so that they will lay a lot of eggs," Nancy said.

"All of you are right," said the teacher. "You feed your animals so that they will grow big. But you also feed them so that they will be strong and grow in some other ways, too. Your 4-H Clubs give you directions that tell you what kind of food to give the different animals so that they will grow the way you want them to. If you follow these directions carefully, you will have healthy animals even though some of you do not win prizes.

"Perhaps there will be a prize for the healthiest boy and girl at the fair, too. Do you know what to do to be as healthy as possible? Eating the right foods is the most important thing for you to do, too. In this unit, you will learn why."

What does food do for you?

HAVE YOU EVER stood up against the wall so that your father or mother could measure how tall you were? Probably a mark was made on the wall level with the top of your head. A few months later, you were measured again to see how much you had grown. Perhaps you are measured and weighed at school in the fall and in the spring, or even every month. Your parents and teachers want to see how much you are growing.

The doctor in the picture on this page is measuring a five-year-old boy's head and body to study his growth. She will do this every year until he is full grown. She can tell a great deal about the way children will look when they grow up by measuring them when they are young. You have probably noticed that we do not all have the same body size and shape. So your growth should be compared with what it was before to find out whether you are growing as you should. When your growth is measured in this way, you are compared with yourself and not with someone else who has a different body size and shape.

Growing taller and weighing more are two signs that you are healthy. You should be growing some all the time. If you are not growing much, your mother probably tries to get you to eat better meals. She knows that food makes you grow bigger.

But just because you may not grow as big or as tall as some of the others in your class does not mean that you are not healthy. Other things besides growing bigger show that you are healthy. Here are two stories to help you see that food does other things for you besides making you grow.

One day, a famous woman scientist received a letter. The man who wrote the letter said, "Please tell me how to grow a new set of teeth. I need them." Of course, the scientist could not tell this man how to grow a new set of teeth. But she could tell him how he might have kept his teeth healthy so that he would not need new ones. This scientist had been working for many years to show people that eating the right kind of food will help them to keep their teeth strong and healthy.

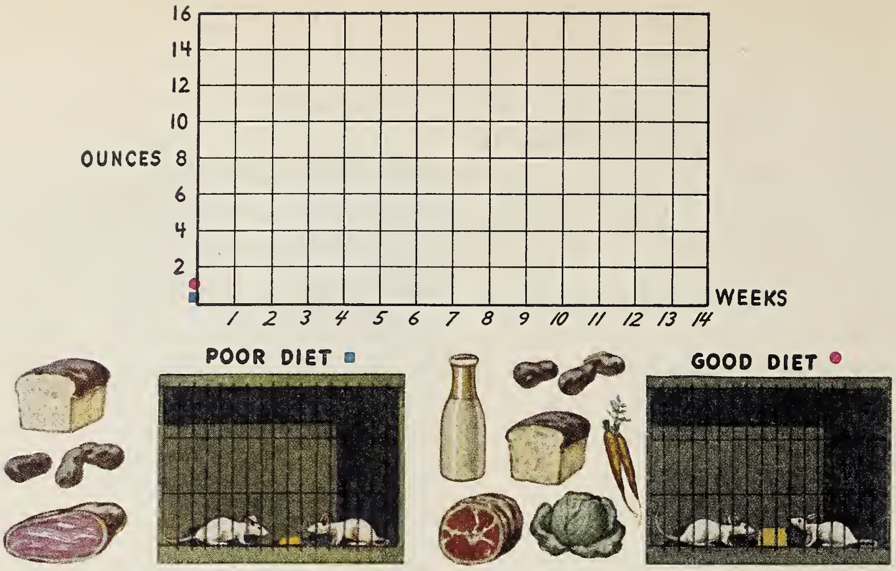
In some parts of the United States, not long ago, many people were suffering from a serious disease. The doctors could not find out what caused the disease, and they could not find out how to cure it. The government sent a doctor to see if he could find out what caused the disease. He studied everything that might help him find out what was wrong. He studied the food that people ate. He thought that perhaps food had something to do with the disease. He did some experiments and found that he was right. People who ate certain foods did not get the disease. People who did not eat these foods got sick.

These two stories show you that food does other things for you besides making you grow bigger. The proper food helps you grow strong, healthy teeth that will last you all your life. It can help you grow a healthy body as well as a bigger one. Some kinds of food make your bones grow strong and straight. Some kinds give you a good, clear skin. Some foods protect you from certain diseases. When your body is very healthy, it can fight disease better. You may not catch so many colds if your body has had enough of the proper kinds of foods.

You probably play and work all day without ever thinking about what makes your body go. But your body could not do all the things it does without energy to make it go. You remember that some foods are energy-giving foods. They give you the strength to do work. Even at night when you are asleep, your body is working. Your heart is pumping blood to every part of your body. Your lungs are breathing. Your food is being digested. And your body stays warm all the time. The energy that keeps your body going and the heat that keeps you warm come from the energy-giving foods you eat.

All the time you are working and playing, you are using up some parts of your body. You need food to make new blood and new skin and some of the materials that keep your body running properly. You get these materials from the foods you eat.

You can see that your food must do many things for your body. You know that your body cannot get everything it needs from just any kind of food. The boys and girls who are raising animals for a 4-H Club know this, too. They know that *what* they feed the animals is just as important as *how much* they feed them. Perhaps your class can do an experiment that will help you find out what kinds of food you should eat. It will help you if you can watch the experiment while you are studying this unit.



Put the weight of each rat on a chart on the day you start your experiment.

Try to get some white rats that are the same age and about the same size. Divide the rats into two groups. Weigh them all and write down their weights. Feed one group lean meat, bread, and potato and give them plenty of water. Feed the other group the same things but also give them some raw and cooked vegetables and milk as well as water to drink. Give both groups fresh food and water every day and keep their cages clean. Weigh them once a week. Make a chart like the one on this page. Put the weight of the rats on the chart each time you weigh them.

Watch them carefully as they grow. It may be several weeks before you notice much difference between the two groups. Which group grows more? Which rats look healthier? Why do you think they look healthier? What you learn in the rest of this unit will help you answer this last question.

To see if you are eating the foods that will help you grow best, keep a list of the foods you eat at breakfast, lunch, and dinner. Put down everything you eat between meals, too. You will use this food list as you study the rest of this unit.

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1. *Name some things that food does for you.*
2. *How does food help you while you sleep?*
3. *What do you expect your experiments with rats to show?*

People who do such hard work as this need foods that give them plenty of energy.

What foods keep you warm and give you energy?

"IT'S COLD this morning," said John's mother when he came down to breakfast. "You'd better eat a big dish of cereal, some buttered toast, and some bacon. They will help keep you warm."

Do you know why the cold weather made John's mother want him to eat these foods? You probably know that the temperature of your body stays about the same all the time. Even when you go out in cold weather, your body still keeps warm on the inside. This means, of course, that there must be some way of producing heat inside your body. You know, too, that you can move your body and other things. This also takes energy.

The heat that keeps your body warm comes from the food you eat. You have seen that heat is produced when fuels combine with oxygen and burn. A chemical change somewhat like this goes on in your body. Of course, there are no flames in your body as there are in a stove. But foods combine with oxygen in your body. When this happens, heat is produced. Scientists can show that this takes place. They even know just how much heat can be produced from a certain amount of food.

These foods contain large amounts of fat. Fat gives more energy than any other food.

Heat, as you know, is a form of energy. Your body also needs energy for the muscles to do their work. Many different things are going on in your body even when you are resting. Your heart must keep on beating and you must also breathe. Your muscles need energy even when you are quiet. And much more energy is needed when you play or work. The food you eat must produce this extra energy that you need.

Experiments have shown that certain kinds of foods contain materials that make them better than other foods for providing energy. These food materials are called *fats* and *carbohydrates.* They are called fuel foods or energy foods because they supply us with heat to keep us warm and energy to move our muscles. John's mother knew that cereal, buttered toast, and bacon contain a lot of carbohydrates and fats. So she had him eat these foods for breakfast. She wanted him to have the fuel he would need during the day. Because you need fuel each day, you must know which foods contain fats and carbohydrates. Then you will know what foods to eat to supply you with energy.

Have you ever watched your mother unwrap some bacon that was wrapped in paper? If you have, you probably noticed large grease spots on the paper. You can always tell whether food has fat in it by press-

Foods containing carbohydrates give your body warmth and energy, too.

ing some of the food against a piece of paper. If it leaves a greasy mark, the food contains fat. This is a test for fat. Fat is the substance that makes foods greasy or oily. Get some different kinds of foods and give them this test. Which ones have fat in them?

Butter, lard, and margarine are probably the fat foods that you know best. They are almost entirely fat. Meats have fat in them. Some meats have much more fat than others. If you tested the yolk of a hard-boiled egg, cheese, and nuts, you found that they have fat, for they leave a greasy mark on the paper, too.

Olive oil and peanut oil also make a greasy mark. These liquids and other oils in foods are like fats. When we talk about fats in this unit, we mean oils, too.

And now let us see which foods contain carbohydrates. Starch and sugar are carbohydrates. It is easy to tell when you are eating sugar or a food containing sugar. Any food that has a sweet taste contains sugar. Oranges, bananas, grapes, apples, and berries are all foods containing sugar. Your mother makes pies, cookies, cakes, jellies, candy, and preserves. Usually she puts sugar in them to make them sweet. You will probably have no trouble deciding if a food has sugar in it.

You may not know when you are eating starch. You have probably seen starch that is used in cooking

How could you tell whether these foods have starch in them or not?

and also starch that is put in clothes after they are washed. This starch is a fine white powder. But starch does not look like this in your food. Then how can you tell if you are eating starch?

Get two glasses of water. In one glass of water, put a teaspoonful of starch and stir it. Then put a few drops of iodine in each glass. What happens? What color is the liquid in each glass? The one with the starch in it turns purple or black. Because this always happens when iodine is added to starch, scientists use this test to see if foods have starch in them.

Cut a slice of potato and put a few drops of iodine on it. Is there starch in the potato? Test some other foods, such as cereals, bread, and different fruits and vegetables. Also cut open a corn seed and a bean seed and test them. Some foods have more starch in them than others. Seeds, potatoes, bread, and cereals have much starch.

Fats and carbohydrates are compounds. They are made of three elements—carbon, hydrogen, and oxygen. They are made of the same elements, but they have not the same amounts of each of these elements in them. Fats have less oxygen than carbohydrates. Carbohydrates supply only about half as much energy as the same amounts of fats do. But we eat more foods with carbohydrates in them than fats. So most of our energy comes from carbohydrates.

The amount of fuel foods a person needs depends partly on what he is doing and partly on where he lives. People who are doing very hard work outdoors need more energy than someone who is sitting inside at a desk. You need more energy foods when you skate or play outdoors in winter or work in your garden in summer than when you just stay inside and play quiet games.

People who live in cold climates can eat more fats than those who live in hot ones. Their bodies need extra fuel to keep them warm. Wherever you live, you need enough fuel foods to supply you with the energy you need to keep warm and move your muscles.

1. *What is a fuel food? Why is it called this?*
2. *How does your body get energy from food?*
3. *What are two uses of the energy you get from food?*
4. *Name some foods that contain fats. Which of them did you eat yesterday and today?*
5. *Name some foods that contain carbohydrates. Which of these did you eat yesterday and today?*

What foods help you grow and keep healthy?

If you were measured at the beginning of school in the fall, you probably found that you had grown taller since last spring. How much did you grow? One of the things that foods do for you is to make you grow. Foods also help your body to repair the parts that wear out as you work and play. Foods make new blood, and they make certain materials that keep your body working well.

Many foods contain a material called *protein.* Protein contains the elements carbon, oxygen, and hydrogen, just as the fats and carbohydrates do. But protein always has one more element, too. It always has nitrogen in it. Sometimes protein contains the elements sulphur and phosphorus.

The lean part of meat is made of protein. Protein is found in milk, too. Cheese is made from milk, and so it gives you protein. Eggs, fish, and a few vegetables like peas, beans, and soybeans have a great deal of protein

Foods like the ones in this picture provide protein for building your body.

in them. You see that there are many kinds of foods that supply protein to our bodies.

Protein is often called the body-building food. It is used to build up your muscles and other parts of your body. If you fall down and skin your knee, protein helps make new skin. Your body can and does use protein to give you energy, but protein is used mostly as a building material. Right now you are growing quickly and need to give your body plenty of body-building foods.

But protein is not the only material in food that you need to grow and keep your body healthy. Your mother probably gives you a glass of milk to drink with your meals. Milk is one of our very best foods. It contains fat, sugar, and protein. It contains two elements that your body needs to make bones and teeth. One of these elements is calcium, and the other is phosphorus. The hard parts of your bones and teeth are made of calcium phosphate. This is a compound of calcium and phosphorus combined with oxygen.

Calcium and phosphorus are called *minerals*. Without these minerals, your bones would not be strong enough to hold you up or to protect the soft parts inside your body. And you could not bite into foods and chew them with your teeth. Much of your food would have to be chopped up before you could eat it.

If you eat plenty of these kinds of foods, you will be getting the minerals you need.

If you can get a slender chicken bone, you can do an experiment that will show you very well what your bones would be like without calcium. Put the bone in a dish and cover it with strong vinegar. Let it stay there for several days. What can you do with the bone when you take it out of the vinegar? Can you bend it enough to tie it in a knot? The acid in the vinegar dissolved the calcium in the bone. There is no longer any calcium in the bone to make it stiff. It has become soft enough to bend.

Your second set of teeth must last for the rest of your life. You can see why it is very important to keep your teeth strong and healthy. Calcium and phosphorus are being used up in your body all the time. You need to keep taking in more to replace what is used up. Milk is the best food to give you calcium. But many vegetables give you a little calcium, too. Milk, egg yolks, cheese, liver, and some vegetables also have phosphorus in them.

Your body needs other minerals besides calcium and phosphorus. Scientists have found that you need about fourteen different minerals to keep your body healthy. You get enough of most of them in your food without worrying about it. But you need to choose your food well to get enough of some of them. You need iron for your blood. Liver, prunes, lean meat, egg yolks, raisins, and potatoes are some of the foods that contain iron.

Another important material your body needs is iodine. Iodine is one of the elements. You might get enough iodine if you were to eat plenty of fish, oysters, clams, and other seafoods. But to make sure that we in Canada get enough of this important mineral, all our table salt now has some iodine in it. It is called "iodized" salt. Look at the package of salt in your kitchen cupboard and you will see that it is labelled "iodized."

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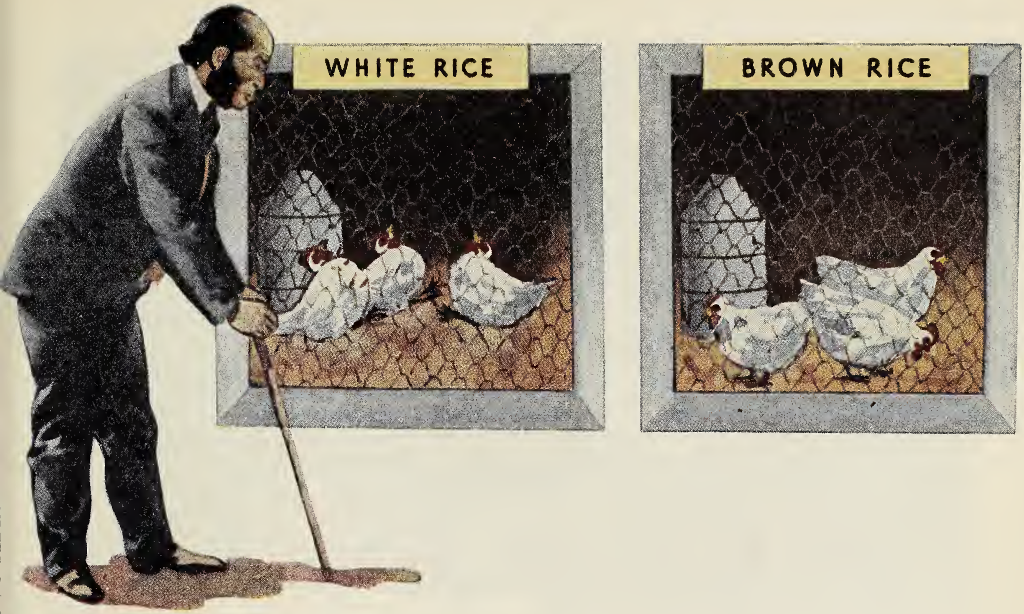
1. *What kinds of foods do you need to build new body material?*
2. *Name some foods that contain fairly large amounts of protein. Which of these have you eaten yesterday and today?*
3. *Why must you eat foods that contain minerals? Name some minerals that you need.*
4. *How are protein foods different from fat foods and carbohydrate foods?*

How do vitamins help you keep well?

MANY YEARS AGO, sailors on long sea voyages used to have a disease called *scurvy*. This is a very painful disease. The mouth becomes sore, and the gums bleed. The joints swell up, too. In those days, people did not know how to keep foods fresh. Sailors could not take fresh fruits or vegetables with them on long voyages. At last, someone discovered that the sailors did not get scurvy if they drank lime juice. After that, ships carried big bottles of lime juice with them. Something in the lime juice prevented scurvy, but no one knew what the something was. The same something is also found in lemon juice, orange juice, and tomato juice.

A doctor on an island in the south Pacific Ocean had many people in his hospital who were sick with a disease called *beriberi*. This disease made their legs so weak that they could not stand up. One day, he noticed that some chickens in the chicken yard near the hospital were acting in much the same way as the people who had beriberi. Their legs and feet were weak, and they could hardly stand up. Then he noticed that the chickens were being fed white rice. This was what the people in the hospital were eating, too.

The doctor found out that the little boy who was feeding the chickens sometimes bought brown rice. This brown rice was cheaper. Then the doctor noticed something



that set him to thinking. The chickens did not get sick when they ate the brown rice. Could this disease have something to do with what the people and the chickens ate?

This doctor was a good scientist. He did an experiment to try to find the answer to his question. He put some chickens that were not sick in a pen and fed them on white rice. They all got sick. Then he gave them brown rice, and they got well. He knew that white rice is made by grinding off the brown outer layers, or hulls, of the grains of rice. He found that there was something in these brown outer layers that could keep chickens and people from getting beriberi. The doctor had made a great discovery. But it was many years before scientists found out what the material in the rice hulls is.

Perhaps you have guessed by now that the material in the lime juice and the material in the rice hulls are *vitamins*. The word vitamin was made up by scientists as a name for these materials. For a long time, scientists did not even know what the materials were or how many of them there were. They called the first vitamin they discovered *vitamin A*. The next one was called *vitamin B*, and so on. Later, they found that there were several kinds of one vitamin. They have found that vitamin B is at least ten different vitamins. So they named them B_1, B_2, and so

You will not need to take vitamin pills if you eat plenty of these kinds of foods.

on, until they could find out what material there was in each one. Each vitamin helps your body in certain ways. Foods that contain vitamins are often called *protective foods,* because they protect us from certain diseases.

Vitamin A keeps you growing well. It keeps the skin inside your mouth and throat healthy. But vitamin A is especially important for your eyes. It keeps you from getting certain eye diseases, and it helps your eyes see better when the light is dim and even when it is dark. Aviators who fly planes at night eat extra amounts of vitamin A to help them see better. But everyone needs plenty of this vitamin to keep his eyes in good condition. Vitamin A is found in butter and is often put in margarine. Carrots, tomatoes, and spinach are vegetables that will supply you with vitamin A.

The vitamin in the brown rice is called vitamin B_1. Vitamin B_1 helps you grow properly and gives you a good appetite. We do not eat so much rice in our country as people do in the part of the world where the doctor discovered the material in the rice hulls. But we eat lots of wheat. Wheat grains are like rice grains. Wheat has most of the vitamin B_1 in the hull and in the part that grows into the new plant. In white flour, the hull and the part that makes the new plant are usually taken out. When this is done, we are losing vitamin B_1 from the flour. These parts are not taken out of the whole-wheat flour, and so it has more vitamin B_1 in it.

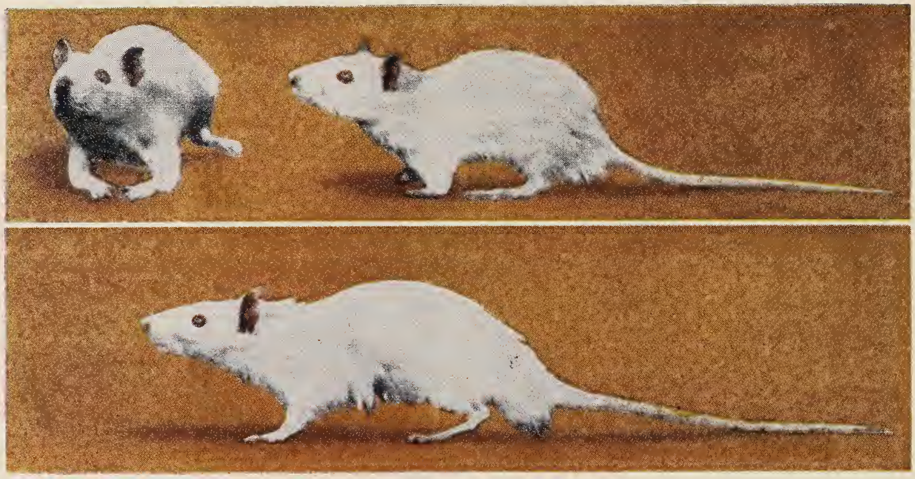
If we eat bread and cereals that are made of the whole grain, we get the vitamin B_1 that we need. Scientists now know how to make vitamin B_1, and it can be put into white flour. Perhaps you have heard about or read about white bread that has been *enriched.* That means that vitamin B_1 has been put into the flour or into the dough before the bread was baked. Your mother may be able to buy enriched flour to use when she bakes. Milk, rolled oats, roast pork, potatoes, peas, and other vegetables have vitamin B_1 in them.

The vitamin in the lime juice is called vitamin C. Besides preventing scurvy, vitamin C helps your body heal when you cut yourself or burn yourself. It helps your body use the calcium in food for your bones and teeth. But your mother does not have to keep a bottle of lime juice for you to drink. Oranges, grapefruit, tomatoes, and cabbage have vitamin C in them. Many other fruits and vegetables have vitamin C. You will get enough vitamin C if you eat plenty of fruits and vegetables.

This baker is putting vitamin B_1 into the dough he is mixing.

Does your mother give you cod-liver oil during the winter? If you take cod-liver oil, you are taking it to get an extra amount of another very important vitamin. This is vitamin D. Vitamin D makes your bones grow straight and strong. It also helps your teeth. Children who did not get enough of this vitamin when their bones were forming and growing are often bowlegged. Other bones in their bodies may be badly formed, too, because of a disease. Scientists call this disease *rickets.* Vitamin D helps prevent rickets.

Vitamin D is found mostly in fish. That is why you take oil made from the livers of codfish, halibut, and sharks if you need extra amounts of vitamin D. You also get it when you eat fish, liver, and egg yolks.



The rat on top had no vitamin D in his food. The one below had plenty of vitamin D. Do you think the vitamin D helped give this rat stronger bones?

But vitamin D is different from the others in one important way. Your own body can make vitamin D for you if you are in the sunlight enough. But in the wintertime there are many days when there is no sunshine. Also, when you play outdoors in cold weather, most of your skin is covered with heavy clothing. So in winter you may need to take an extra amount of vitamin D.

Sometimes foods are *irradiated* to give them more vitamin D. To do this, artificial sunlight is allowed to shine on the foods. Milk, butter, and margarine are often irradiated.

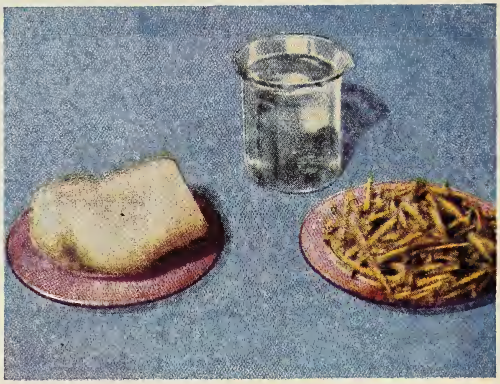
You probably hear people talk a lot about vitamins and the different kinds of vitamin pills. Usually you can get enough vitamins without taking pills. But you must eat the protective foods that contain vitamins.

---

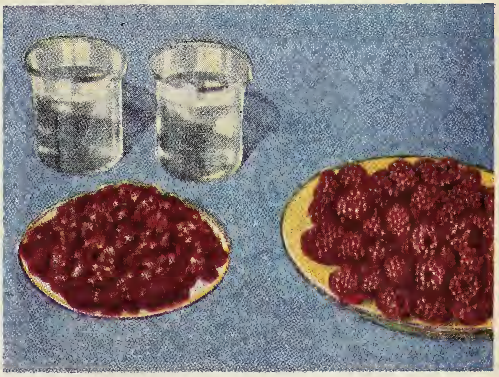
1. *What is a protective food?*
2. *Make a list of vitamins and tell what each vitamin does for you.*
3. *Make a list of vitamins and name some foods that contain each vitamin.*
4. *Why are scientists' experiments with food so important to you?*
5. *Should you take vitamin pills just because you heard someone say they were good for you?*

What does water do for your body?

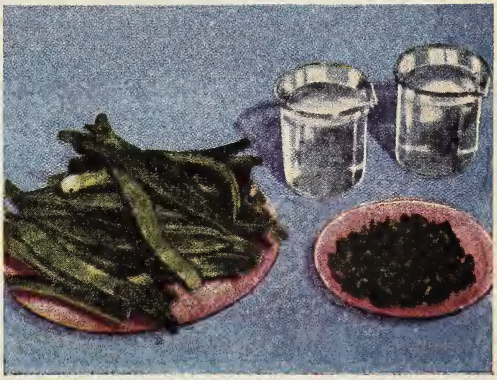
PROTEINS HELP your body grow. Fats and carbohydrates give you energy and keep your body warm. Minerals and vitamins help you grow and keep your body healthy. There is just one more thing your body needs to keep it well. That is water. Nearly three fourths of your body is water. You should drink at least four glasses of water each day. Your body needs much water because your blood is mostly water. You need water so that your body can keep on making the blood it needs.

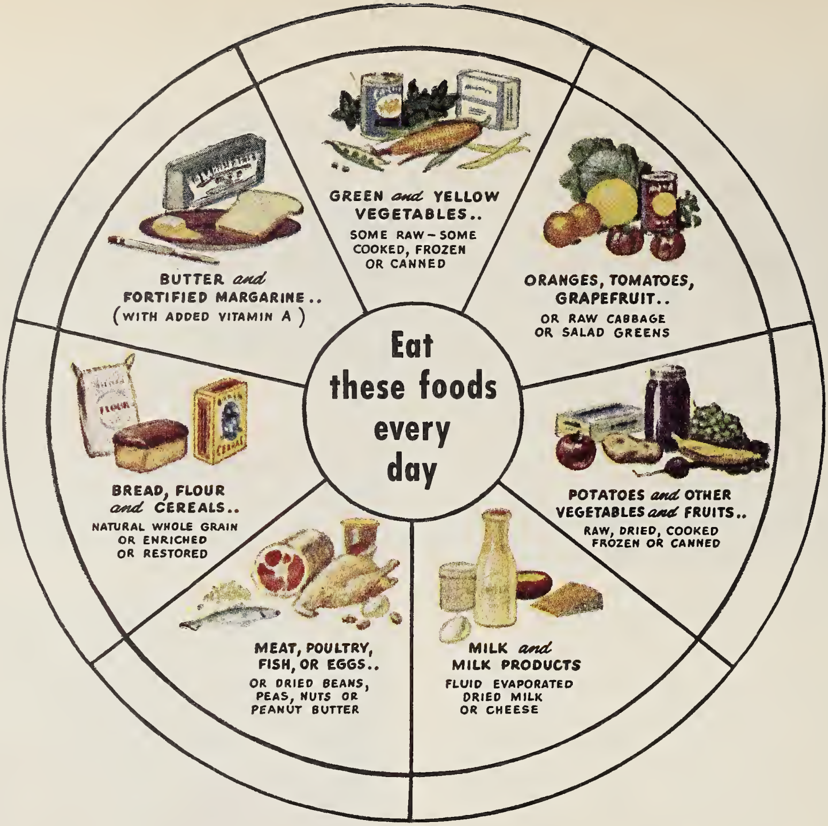


Water also acts in the same way as the cooling system in an automobile. Water helps keep your body at the right temperature. Water helps dissolve your food. Water carries off waste materials from your body. When you play hard or work hard, you perspire. Perspiration is water that is carrying some of the waste materials from your body.



Scientists know that a person loses four or five pints of water from his body every day. You cannot replace all of this water even if you do drink four glasses a day. But you can get water in milk, fruit juices, juicy fruits, and vegetables. Many things you eat have much water in them. Look at the pictures on this page. They show how much water you would get if you ate these amounts of potatoes, raspberries, or beans.

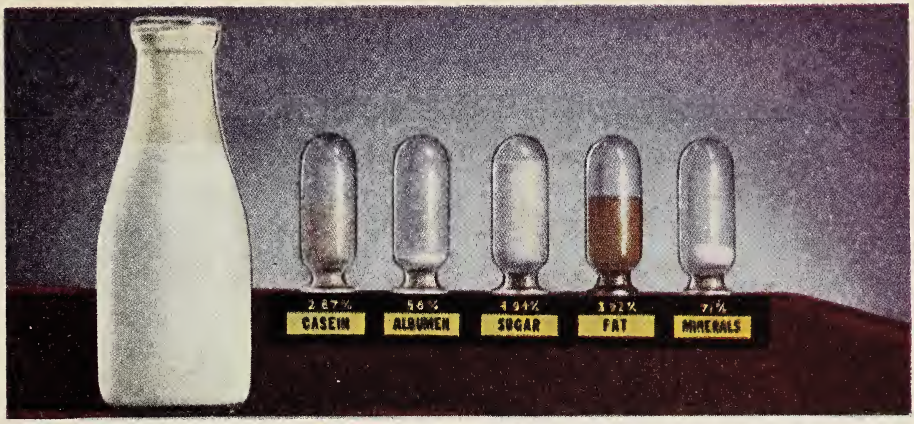



Eat these foods every day
GREEN and YELLOW VEGETABLES..
SOME RAW – SOME COOKED, FROZEN OR CANNED
ORANGES, TOMATOES, GRAPEFRUIT..
OR RAW CABBAGE OR SALAD GREENS
POTATOES and OTHER VEGETABLES and FRUITS..
RAW, DRIED, COOKED FROZEN OR CANNED
MILK and MILK PRODUCTS
FLUID EVAPORATED DRIED MILK OR CHEESE
MEAT, POULTRY, FISH, OR EGGS..
OR DRIED BEANS, PEAS, NUTS OR PEANUT BUTTER
BREAD, FLOUR and CEREALS..
NATURAL WHOLE GRAIN OR ENRICHED OR RESTORED
BUTTER and FORTIFIED MARGARINE..
(WITH ADDED VITAMIN A)

What habits will help you get the proper foods?

YOU MAY THINK you need to spend most of your time eating to get all the fats, carbohydrates, protein, minerals, and vitamins your body needs. But if you remember the kinds of foods that have these materials in them, you can get all of them you need in your three meals a day. Luckily, many foods have more than one of these important materials in them.

The chart on this page shows you how to choose your foods so that you will get the right food materials. Each group shown in the chart does one of the important things for your body that you have learned about. In Canada we have a set of rules to help us to eat the right amounts of the important foods. They are called Canada's Food Rules. Ask your teacher to write for a copy of them and keep it in the classroom where all the pupils can see it. "Follow Canada's Food Rules every day" is a good motto for you to take as your own.



Scientists can separate the different materials in milk and find out how much of each material there is in a quart of milk. Casein and albumen are the protein parts of milk that they find in the curd.

If you follow Canada's Food Rules, you will have enough of all the different foods instead of eating too much of one kind and not enough of another. This does not mean that you should eat only the foods listed there. But it does mean that you should be sure to eat these foods first. When you have formed the habit of eating these foods, you will probably find that you like many things that you thought you disliked. You can form the habit of liking foods instead of disliking them.

Why should you form the habit of drinking at least three glasses of milk every day? Let us take some milk apart, in order to see why it is important to drink plenty of milk. First, take the cream off the top of a bottle of milk. Put it into a glass jar. You can churn this cream into butter by beating it with an egg beater or shaking it in a glass jar with a tight cover. What food material is there in this part of the milk? There is fat. So you see that milk has fuel food in it.

The milk that is left after the cream is taken off is skim milk. Let this part stand until it is sour. Heat it a little. Some white, fluffy material appears. This is called the *curd*. Strain it, salt it, and you will have some cottage cheese. Curd has much protein in it. So you can see that milk has a body-building food in it.

The liquid part that is left is called the *whey*. Taste it. Is it sweet? There is sugar in it. Here is another fuel food. Heat the liquid in a shallow dish until it evaporates. What is left? This sticky material in the bottom of the dish has some sugar, calcium, and phosphorus in it. So you can see that milk has a carbohydrate and some minerals in it, too.

You have found four of the food materials that you need in this bottle of milk. Besides these important materials, milk also has vitamins in it. Do you see why milk is called the perfect food? You should drink at least three glasses of milk every day.

Do you sleep so late in the morning that you haven't time to eat a good breakfast before you go to school? If you do, you are missing a very important meal. You are trying to run your body all morning without giving it enough fuel for energy. You need to eat a good breakfast to begin the day. A healthful breakfast gives you vitamin C. Oranges, grapefruit, the juices of these fruits, and tomato juice have good supplies of this vitamin.

For fuel food, you need some cereal and some buttered toast. If you use a whole-grain cereal and whole-wheat or enriched bread, you will get vitamin B_1 and some minerals at the same time. An egg for breakfast three or four times a week gives you protein and some of the minerals and vitamins. Sometimes when it is very cold or you are going to do a lot of exercising, you may want to eat bacon or sausage for breakfast. This fuel food tastes good, but you can usually get enough fuel food without it.

Milk on your cereal and a glass of milk to drink will give you some of the calcium and phosphorus you need as well as some vitamins. Coffee and tea are not good for you. They have none of the foods you need.

Look at the lists of your meals that you have been keeping. Do you always eat a breakfast that includes the foods you need? If you do not, talk

One pint of milk gives as much calcium as twenty servings of fruits and vegetables.

with your mother or your teacher about some way to get the kind of breakfast that is best for you. You will be surprised to find how much better you will work and play during the morning if you eat the right kinds of foods for breakfast.

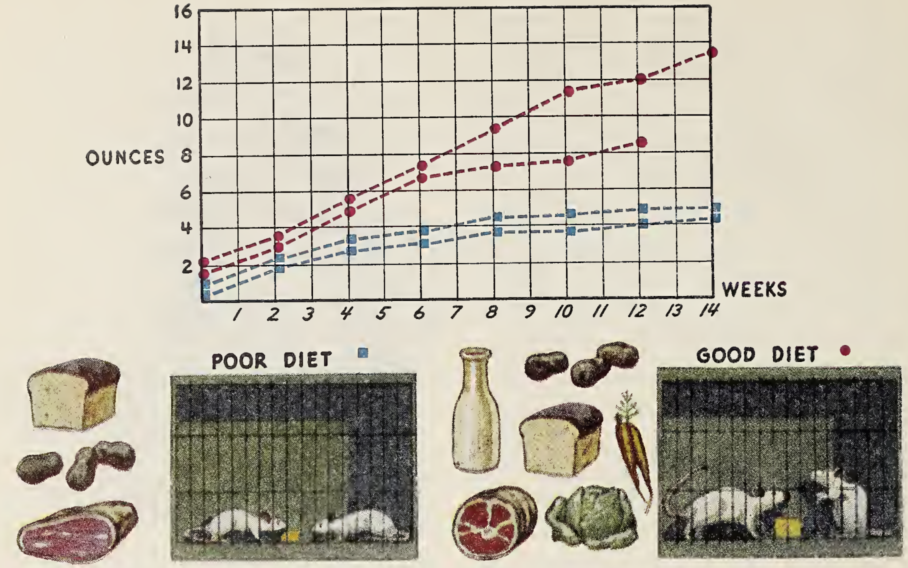
For lunch do you always have some of the foods listed in Canada's Food Rules? If you go home to lunch, your mother has it ready for you. But you may take your lunch to school or buy it in the school cafeteria. Do you eat a healthful lunch, or do you just drink some "pop" and eat some sweets, because they are the things you like best?

If you take your lunch, your mother can plan it so that you always get some of the important foods. Your sandwiches can be made with whole-wheat bread and something like peanut butter, cheese, or chopped egg for the filling. You can take lettuce, carrots, a tomato, or some fruit to give you vitamins and minerals. If your lunch box has a thermos bottle, you can have milk. Or you may get milk at school. In the winter when it is cold, hot soup made with milk tastes good and gives you some of the milk you need every day. Some fruit, a milk pudding such as rice and custard, or ice cream makes a good dessert.

When you are picking out your food in the school cafeteria, you may find it much harder to choose the things you should eat. Sometimes you may want to eat one or two things you like instead of choosing a meal that has the different foods you need. But you can make a game out of choosing a lunch that tastes good and is also good for you.

The picture on this page shows a girl and the lunch she picked out. She has cream of tomato soup, milk, a whole-wheat roll and butter, and some lettuce salad. For dessert, she has apricots and oatmeal cookies. Has she chosen her lunch well? Why do you think so? Now look at your food list to see what you have been eating for lunch. Have you been choosing the proper foods?

Sometimes after school you are hungry. It is better to eat some fruit or drink a glass of milk than to eat



What does the experiment with the white rats show you about eating the proper foods?

candy or to drink "pop." Candy gives you energy, but it takes away your appetite for your meals. If you eat candy, it is much better to eat it right after lunch or right after dinner.

"Pop" is mostly water with some sugar and flavoring in it. Like candy, it will spoil your appetite. Then you will not feel like eating your dinner, because you haven't room for the foods that you need.

Dinner is very important. If you have been playing after school or working in your garden, you are hungry. Dinner is a good time to have some of the necessary foods that you have not eaten during the day. Dinner should probably start with meat and potatoes and one other vegetable. If you have not had any fresh fruits or vegetables during the day, a lettuce and tomato salad would be good. For dessert, you might have fruit or custard or some ice cream. If you have not had at least three glasses of milk during the day, drink a glass of milk with your dinner. Look at your food list again. Have you been eating healthful dinners? What can you do to improve them?

Planning meals is not always an easy job. But if you know the foods that give you the things you need, you can eat and be healthy. Of course, you do not need to remember just which vegetables and fruits have each vitamin and mineral. If you eat plenty of meat, fruits, vegetables, milk, butter, and whole-grain bread and cereals, you will get enough of the different food materials you need for good health.

If you were able to get some white rats, you have been feeding and watching the two groups as you studied this unit. How have they grown? Which group looks healthier? The rats that had all the different kinds of food are big, playful, and friendly. But the others are small and do not want to play. The two groups of rats have grown differently, and they act differently. You can see why it is important to eat the proper foods.

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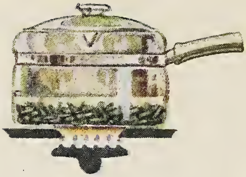
1. *List all of the things that you can do to make sure that you are getting the right foods.*
2. *Explain why you should eat some of each of the different food materials every day. Do your meals include these foods? How do you know?*
3. *What does this mean?* Follow Canada's Food Rules every day.
4. *Why is milk such an important food?*
5. *What have you learned about eating each of these?*
   Eggs Candy Whole-wheat bread Soup Vegetables

What does cooking do for your food?

YOUR MOTHER has to do more than plan meals and buy food to give you something to eat. Before food can be eaten, it has to be prepared. And much of it has to be cooked. Your stomach could not digest some foods very easily if they were not cooked. Many foods would not be very appetizing to eat raw. People in some parts of the world eat raw fish and raw meat, but we are not used to doing that in our country. Another reason for cooking food is to kill germs. Certain germs can be killed only by cooking the food. But sometimes when food is cooked, the vitamins are destroyed and many of the minerals are lost.

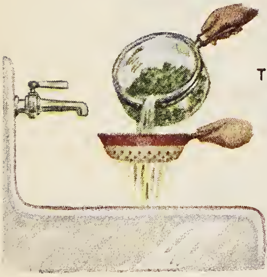
There are many ways of cooking foods, and everyone has a favorite way of doing it. Some people like to fry a great deal of their food. Fried foods are harder for your stomach to digest than foods cooked in other ways.

As you know, vegetables are among the most important foods to eat to get the minerals and vitamins you need. But many of the minerals and vitamins are often lost while the vegetables are being prepared and cooked. Vegetables must be washed before



USING A SMALL AMOUNT OF WATER

USING A LARGE AMOUNT OF WATER



THROWING AWAY WATER FROM VEGETABLES

USING WATER FROM VEGETABLES FOR GRAVY

USING BEET GREENS

THROWING BEET GREENS AWAY

they are used, but they should be washed quickly. They should not be allowed to stand in water before they are cooked.

Cutting vegetables up into small pieces makes it even easier for the vitamins and minerals to be lost. When you peel potatoes, you take off the part that has most of the minerals. Baked potatoes or potatoes cooked with their skins on still have most of their minerals after they are cooked.

When vegetables are boiled in a lot of water, the minerals in the vegetables dissolve in the water. Some of the vitamins may dissolve in the water, too. Usually this water in which vegetables are cooked is thrown away. Then most of the minerals and vitamins you could get from the vegetables are lost.

To save these important food materials, vegetables should be boiled in as little water as possible. And they should be cooked only long enough to make them tender. If there is not too much water in the pan, the juice from the vegetables can be served with them. Then you will be getting all of the minerals and vitamins they have. This juice can be used in soups and gravies, too.

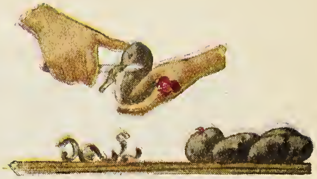
If meat is boiled or cooked with a great deal of water, the minerals, much of the fat, and some of the protein are lost from the meat. Roasting or broiling keeps most of the minerals and vitamins in the meat. So it is best to cook meats in these two ways whenever you can.

Water is not the only thing that takes vitamins from your food. Heat and air also destroy some of the vitamins. Fresh vegetables and fruits have most of their vitamins still in them. The longer they are exposed to the air, the more vitamins they lose. Cooking vegetables and fruits in pans that are covered as tightly as possible helps keep the vitamins in.

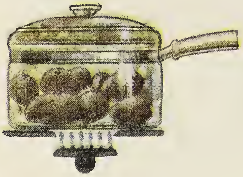
Very often canned vegetables and canned fruits bought in a store have more vitamins than the fresh ones cooked at home. The way they are cooked in a big canning factory keeps out the air. Not so many of the vitamins are destroyed. The juice is kept with the vegetables or fruits, and this has vitamins, too. A very healthful fruit drink can be made from the extra juices in cans of fruit.

Milk is usually pasteurized. This means that it is heated to a temperature of from 142° to 145° F. and kept at that temperature for half an hour. Scientists have found that this kills the germs that may be in the milk. This heat destroys some of the vitamins. But eating other foods makes up for this. It is much safer to use pasteurized milk and get your vitamins from other foods.

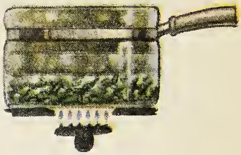
In winter, you want to eat more hot, cooked foods. In summer when it is very hot, you do not need so



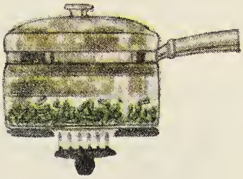
PEELING POTATOES



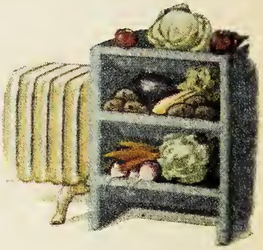
COOKING POTATOES WITH SKINS ON



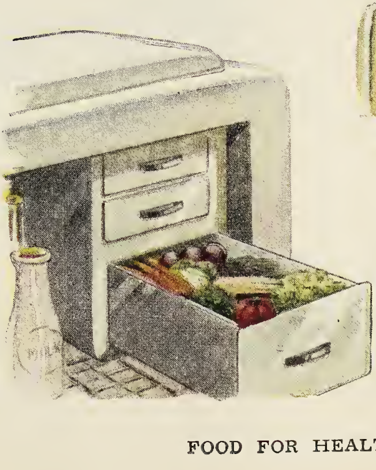
COOKING VEGETABLES IN UNCOVERED PANS



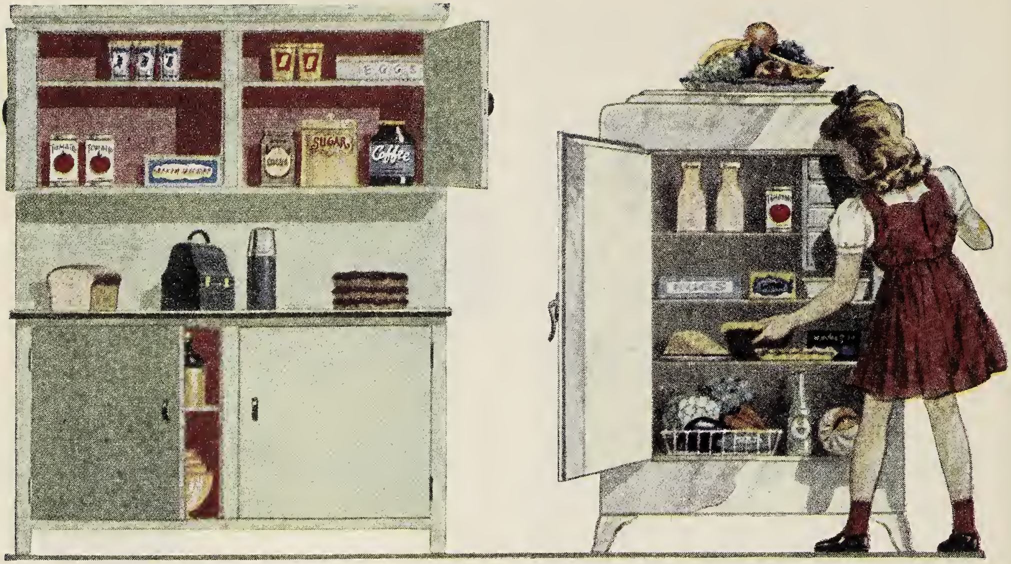
COOKING VEGETABLES IN COVERED PANS



KEEPING VEGETABLES NEAR HEAT



KEEPING VEGETABLES COOL



The girl in the picture is going to help her mother pack her lunch for school. What things could she put in her lunch to give her the proper foods?

much hot food unless you are doing very hard work. Lighter, cooler foods look better to you and satisfy your appetite. Setting the table neatly and attractively always makes the food look better and taste better, too.

1. *What are three reasons for cooking food?*
2. *Look at each pair of pictures on pages 200 and 201. Which one in each pair shows the correct way of preparing or cooking food? Explain your answer.*
3. *Why is milk pasteurized? How is this done?*

QUESTIONS TO ANSWER

1. Why are canned foods sometimes better than fresh foods?
2. How can the things you learned in this unit help you?
3. Why are experiments with the food of animals important to you?
4. This unit is called "Why do you need food?" Give your answer to this question.
5. Why do farmers who raise cows, sheep, chickens, and other animals need to know about foods?

THINGS TO DO

1. Newspapers and magazines often give plans for meals. Look at the meals to see if they are healthful. Cut out the best plans and make a book of plans for healthful meals.

2. Make a chart of Canada's Food Rules and hang it in your schoolroom.

3. Study the list you have made of the foods that you have eaten. Try to decide what you can do to improve your meals.

4. Find out more about experiments with animals and foods.

5. Think of some experiments to show that fruits and vegetables contain a large amount of water.

6. Ask your school nurse or a doctor to talk to your class about foods and good eating habits.

7. Explain why doctors are interested in getting people to eat the proper foods.

8. Make a collection of different kinds of empty cereal boxes. Read the labels and talk about the information given about each cereal.

★ *In Unit Eight You Will Learn* ★

★ How roots help plants get food materials ★

★ How water and air get into the leaves ★ How a green leaf makes food ★

★ What becomes of the food made by a green leaf ★

★ How plants that are not green get food ★

⋆ UNIT 8 ⋆

Where Does All the Food of the World Come From?

WHERE DOES ALL the food of the world come from? Perhaps that question is too hard for you to answer. Very well. Try answering this question. Where does all the food you eat come from? Perhaps your answer would be "From the grocery store and meat market." Or if you thought more carefully, you might say, "It comes from animals and plants." That would be a good answer, but it would not be the whole answer.

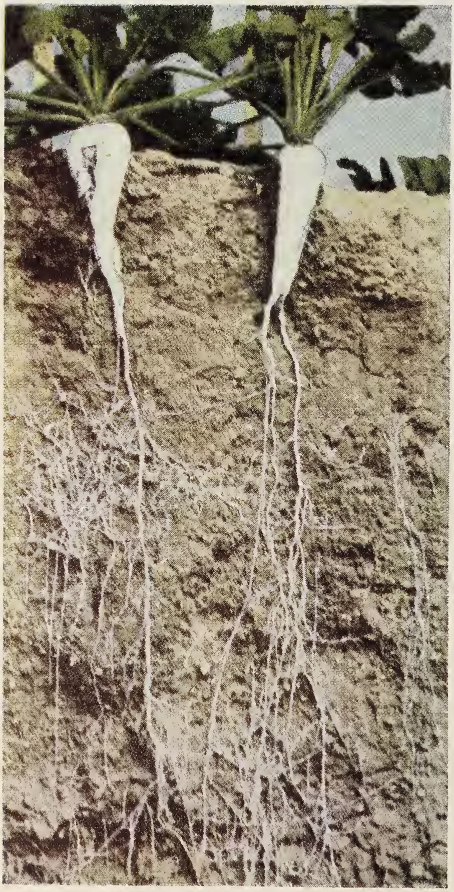
Suppose you think of all the kinds of animals you use for food—cows, sheep, pigs, chickens, turkeys, ducks, and fish. What do they use for food? Perhaps you say that turkeys and chickens eat insects, such as grasshoppers and crickets, as well as grain. And you may say that big fish eat little fish and frogs. That is true. But what do grasshoppers and crickets use for food? And what do little fish and frogs use for food?

Have you begun to guess where all the food comes from? In Unit Seven, you learned about carbohydrates, fats, proteins, and minerals. You learned why your body needs them. If it were not for green plants, you could not get these carbohydrates, fats, and proteins. Green plants make these foods, and we eat them when we eat the plants or the parts of plants. Green plants make these foods, and the animals we use for food eat the plants or eat other animals that eat the plants. Plants do not make minerals. But they take minerals from the soil and change them so that we can eat them. You know that the green plants are not making the food just for us. They are making it for themselves. It is their food as well as ours.

When you look at a green plant, you are looking at one of the world's food factories. Strange and wonderful things are going on inside the green leaves of the plant. It is doing something that the world's greatest scientists cannot do. Let us look carefully at a green plant. Then we can find out how it gets materials to make food.

How do roots help plants get food materials?

If you just look at a green plant growing in the ground, you can see that there are only two places where that plant can get the materials it needs for making food. One place is the soil. The other place is the air. But plants cannot use soil and air for food any more than you can. They must take materials from the soil and from the air and make food out of them. If we want to discover how green plants do this, we have to study what their parts are and how they are put together.



Let us start our study of green plants by looking carefully at the roots. If you can, go out into a field or a vacant lot and dig up different kinds of plants. Do not try to pull them out. Take up plenty of soil with them and then wash the soil off so that you will not break the roots. Look carefully at the different roots. Are they all alike?

If you dug up several different kinds of plants, you probably found that the roots of the plants were not all alike. Some plants have one main root with several smaller roots branching out from it. The picture on this page shows some sugar beets. Do you see the large main root with the smaller ones branching from it? Carrots, beets, and radishes have roots like this. Some other plants have no main root. They have smaller roots like branches that spread out in every direction. If you dug up some grass, you found roots of this kind.

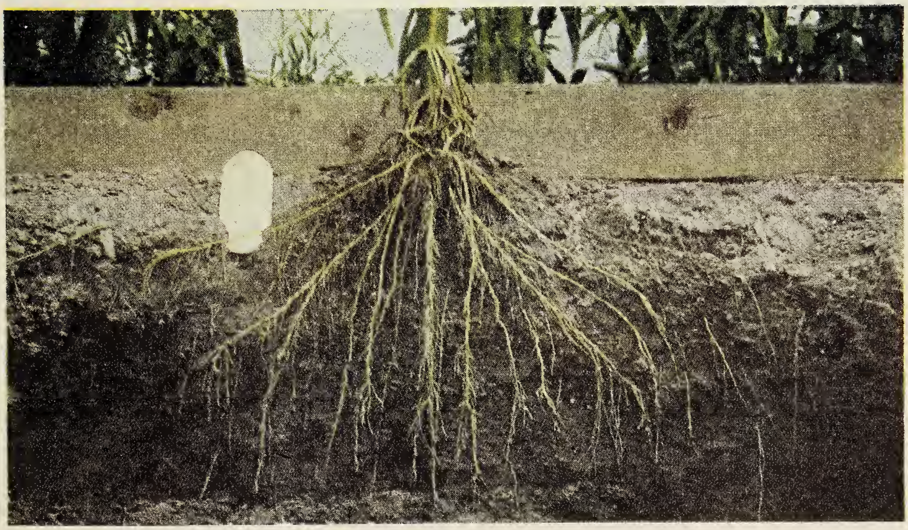
You already know that plants must have water to stay alive. You also know that they get this water from the soil through their roots. But do you know just how the water gets into the roots?

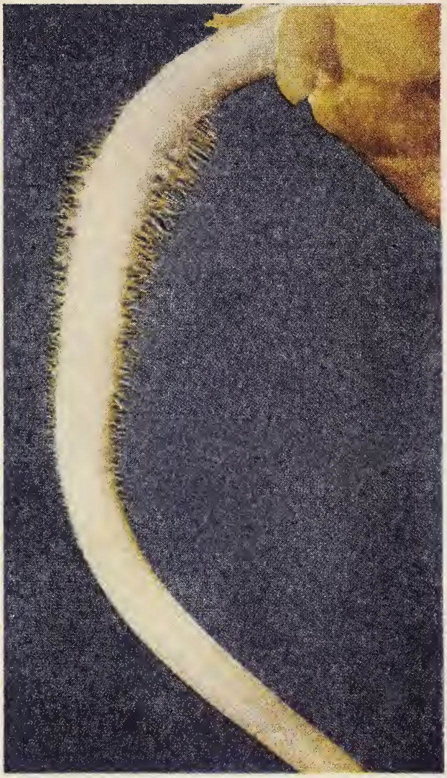
The large roots of a plant do not take in the water. The smaller roots that branch off from them do not take in water, either. But on these smaller roots there are very tiny parts as small as hairs. They are called *root hairs.* There are hundreds of these root hairs on one small root. They take in water for the plant. The outside of a root hair has a very thin covering. Water from the soil goes into the root hairs through this thin covering. From the root hairs the water goes into the root and then into the rest of the plant.

If you want to see how root hairs look, you can easily grow some. Put a dozen lima beans or several radish seeds on some moist blotting paper in a shallow dish. Do not cover the seeds with water but just keep the blotting paper moist. Keep the dish covered with glass so that the seeds will stay damp.

After the seeds have sprouted, take a magnifying glass and look at one of the roots. You will be able to see many tiny root hairs. Sometimes you can see them without a magnifying glass, because there are so many of them. The picture on page 208 shows

The roots of a corn plant are like grass roots. They spread out in all directions.





how these root hairs look. Once when some boys and girls saw the fuzzy root hairs on seeds that they had sprouted, they thought the plants were moldy and threw them away! They did not know that the fuzz that looked like mold was really thousands of root hairs.

When water from the soil goes into the root hairs of a plant, some very important materials enter with the water. They are minerals from the soil. You know the names of some of the elements in these minerals found in the soil. You have experimented with the elements iron and sulphur, and you know about calcium and phosphorus. You know that we need these elements in our foods. Now you know how they get into our foods from the soil.

Of course, the iron and other elements that the water gets from the soil are not in lumps like iron or sulphur you have seen. The elements are combined with other elements to form compounds that are minerals. These minerals are solids. They cannot get into the root hairs until they dissolve. Only those minerals that will dissolve in water can get into the root hairs. These minerals dissolve in the water that soaks into the ground when rain falls or snow melts.

All water in the ground has some kinds of minerals in it. Minerals are almost everywhere in the soil. They are some of the materials that a green plant needs for making food.

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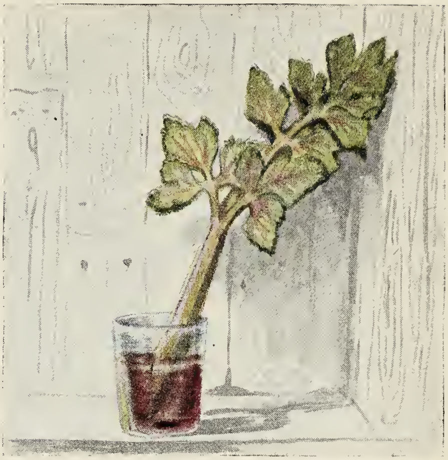
1. *Why must minerals dissolve in water before a plant can use them?*
2. *What parts of a root take in water?*
3. *What will happen if you cut off the root hairs of a plant? Try an experiment to see if your answer is right.*

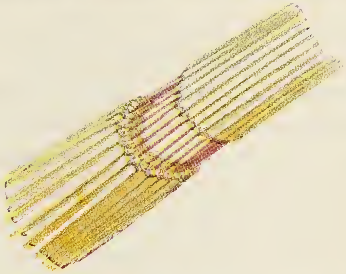
How do water and air get into the leaves?

AFTER THE WATER with its load of dissolved minerals soaks into the root hairs of the plant, it must get up to the leaves before it can be used to make food. How do you suppose the water gets to the leaves? An easy way to find out is to try this experiment. Get a stalk of celery with several leaves on it. Cut off about an inch of the bottom of the stalk. Fill a glass with water and add some red ink to the water to color it. Put the celery in the glass of colored water and set the glass on a window sill where it will be in the sunlight. After a few hours, look at the celery.

You will see that the red liquid has travelled up through tiny tubes in the stem and has gone into the leaves. If you break the stalk of celery, you can quickly find the tubes. They will be colored red by the ink in the water. You can easily take out one of these tubes and look at it. Or cut across the stem. If you can see the groups of red tubes, they will look like the picture on this page. Roots, trunks, and branches of trees and shrubs have tubes that carry water.

Now look at the leaves of the celery stalk that you put in the colored water. In what part of the leaves do you find the colored water? These colored places are the *veins* of a leaf. The tubes that carry water are in the veins.

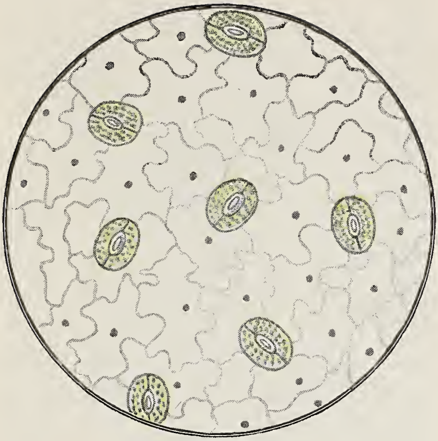




What are the "strings" that you often find when you eat a piece of celery?

The water that has come up from the soil through the tubes in the stem travels through the veins of a leaf. On page 210 is a picture of a leaf that shows the veins. Do you see that they are in almost all parts of the leaf?

Now you have learned how water and the minerals dissolved in it get to the leaves of plants. Before you can understand how a plant makes



food, you will need to know some things about the parts of a leaf.

Plants need water and minerals to make food. They also need one of the gases in the air. People never really understood how air gets into a plant until they began to use microscopes. Then they could see how leaves are made. They found tiny openings on the undersides of the leaves, and they discovered that plants get air through these openings. These openings are really little doorways to let air come into the leaf. Study the picture on this page to see what the tiny openings look like. The picture on the left shows part of the surface of a leaf magnified thousands of times.

If you can look at a leaf under a powerful microscope, you will see hundreds of tiny green dots scattered through the leaf. They make the leaf green. The green material in them is called *chlorophyll.* You cannot see these little dots of chlorophyll except with a microscope. They are very small, but they are very important. No plant can make food unless it has chlorophyll in it. You may see some fungi that are green, but they have no chlorophyll. They cannot make food. When we talk about green plants in this book, we mean only plants that have chlorophyll.

You have now found out five important things to help you understand how green plants make food.

1. The materials that plants need to make food are water, minerals, and one of the gases in air.

2. Minerals dissolved in water get into the plant through the root hairs.

3. The water and minerals go to each leaf through tubes in the roots and stems. They go to all parts of the leaf through tubes in the veins.

4. Air gets into the leaf through tiny openings in the leaf.

5. To make food, plants must have a green material called chlorophyll.

---

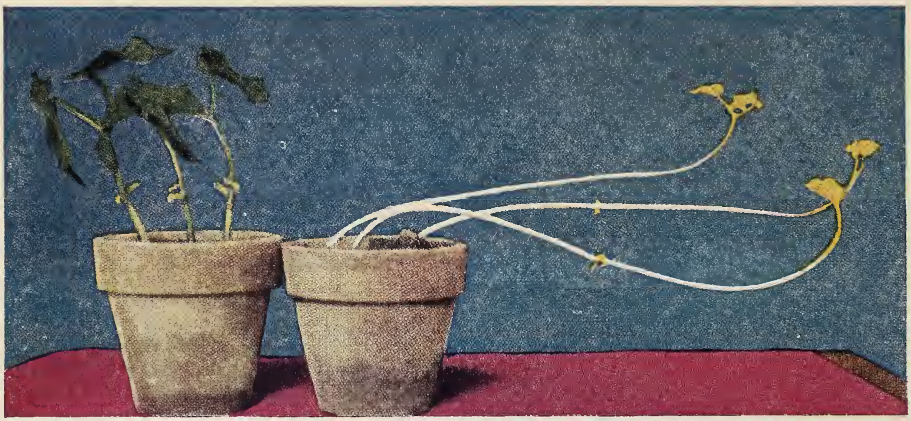
1. *What materials are needed by a green plant to make food? Where does each of these materials come from?*
2. *How does water get from the soil to a leaf of a green plant?*
3. *How does a green plant get the air it needs to make food?*
4. *Why was not all the celery stem colored by the red liquid?*
5. *What is one important use of a plant stem?*
6. *Florists sometimes sell green carnations. How do you suppose they make the white flowers green?*

How does a green leaf make food?

NOW SUPPOSE THAT you could look inside a green leaf and could see what happens there as food is made. How does the plant make the carbohydrates, fats, and proteins that your body needs? The first food the green plant makes is sugar. From the sugar, the plant makes other kinds of food. It may seem strange to you that the sugar that is in your sugar bowl at home was once inside a leaf. But it was. When it was in the leaf, it looked quite different from the sugar that you eat.

You have eaten sugar made from a plant called sugar cane. You probably have eaten sugar from sugar beets, too. Have you eaten sugar from maple trees? Of course, you know that there is no sugar in the soil. And there is no sugar in the air. The green leaf made the sugar out of materials from the soil and the air. In the experiment on page 130, you heated sugar to separate it into the materials that it is made of. You found that sugar is a compound. Plants can make a compound by putting these materials from the soil and air together to make sugar, starch, and other kinds of foods.

Now let us learn a little about how a green leaf puts materials together to make food. Water with its load of minerals comes up from the roots, through the stems, and into the veins of the leaf. Air comes in through the tiny openings in the leaf. One more thing is needed before the leaf can begin making food. Can you tell what



The bean plant on the left was grown in the light for ten days. The one on the right was grown for ten days in the dark.

it is? Try this experiment to see if you can find out. Follow the directions carefully.

Get two plants that are about the same size. Put one on a window sill where the sun can shine on it. Put the other one in a dark closet or any dark place. Water both plants every day. Be sure that the one in the dark has plenty of air, just as the one on the window sill has. Why do you think this is important?

After a week has passed, bring out the plant that has been in the dark. Do the two plants still look alike? Are the leaves green on one plant but yellow on the other? Why does the plant that has been on the window sill look better than the other one? Is it because it had more water and air? What did the plant on the window sill get that the plant in the closet did not get?

If you did the experiment carefully, you found that growing plants need sunlight. Plants cannot make chlorophyll without sunlight. And without chlorophyll, plants cannot make food.

But you have not yet found out what happens to the water and the air in the leaf. Let us see what happens. You know that air is a mixture of gases. One of these gases is carbon dioxide. The green leaf takes carbon dioxide from the air, puts it together with water from the soil, and makes sugar. This is a chemical change.

If you put water and carbon dioxide together, you would get a mixture—soda water. But a green leaf makes a compound—sugar. It puts water and carbon dioxide together and makes a different material. The sugar is not like either water or carbon dioxide. A chemical change takes place in the green leaf.

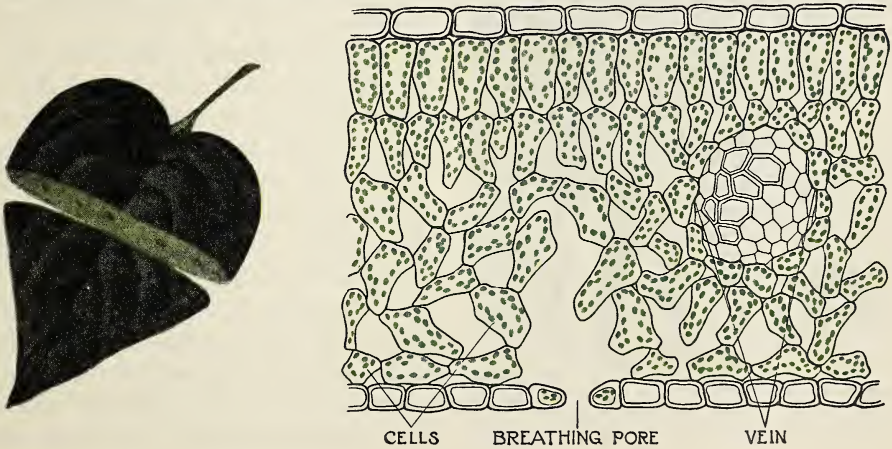
The chemical change takes place in the *cells* of the leaf. The picture on this page shows you what cells are. It shows how part of a leaf looks under a microscope. You can see that the leaf is made up of many tiny box-like parts. These are the cells. The veins bring water and dissolved minerals to these cells. The openings in the leaves bring air to them. The chlorophyll is in these cells. The food is made in the cells.

Do you see now where the black carbon came from when you heated sugar? It was part of the carbon dioxide that the plant took from the air. A chemical change took place, and a compound was made inside the leaf.

This chemical change cannot happen without sunlight. Green plants cannot make food at night, and they cannot make it in dark caves in the earth. Deep down in lakes, oceans, and rivers, there are no green plants, because sunlight cannot go far down into the water. This chemical change cannot happen without the green-colored chlorophyll, either. Plants like mushrooms, puffballs, molds, and yeasts cannot make food. They cannot put water and carbon dioxide together to make sugar because they have no chlorophyll in them.

Scientists have studied the green plants for many years, but they still do not know just how a green plant makes food. They know that a plant needs air, water, minerals, chlorophyll, and sunshine. But scientists do not know exactly how the food is made. They know that sugar is made by the plant, because they can show

If you could cut a very thin slice down through a leaf and look at it under the microscope, you would see the cells and see where the chlorophyll is.



that leaves and other parts of plants have sugar in them. They also know that plants make starch. Sugar and starch are carbohydrates. Plants make fat and protein, too. Scientists do not know how the plants do this.

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1. *What is happening in the green leaves you see?*
2. *Of what use is each of these in making food in a green leaf?*
   Water Sunlight Veins Tubes in the stem Air
3. *How do you know that the making of sugar by a green plant is a chemical change?*
4. *Why does the grass under a board get yellow?*
5. *In Unit One find a picture of a plant that cannot make its food. Why can it not make food?*

What becomes of the food made by a green leaf?

When we collect sap from maple trees, we get the sugar that was made in the leaves and stored in the plants all winter.

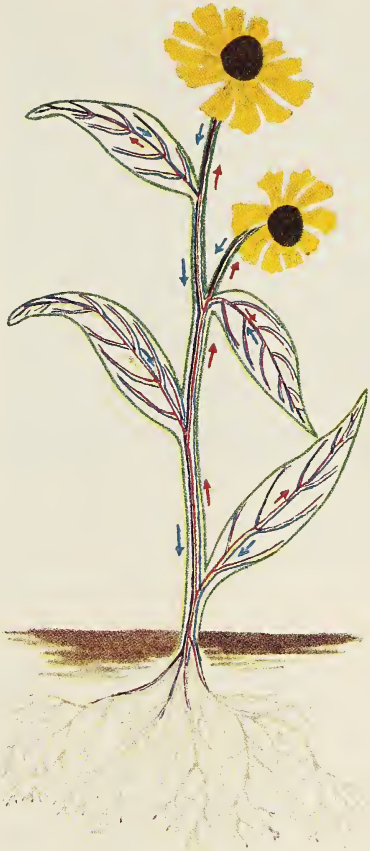
YOU KNOW WHAT becomes of some of the food the green plant makes. You eat it. But before you eat it, what does the plant do with it?

The carbohydrates, fats, and proteins made by the green plant are used by the plant in much the same way your body uses food. The food you eat is carried to every part of your body by the blood. In much the same way, the sap carries materials up and down in plants. You know that tubes carry sap, made of water and dissolved minerals, up to the leaves. The red lines in the picture on the next page show these tubes. Other tubes carry sap with food in it down from the leaves to all parts of the plant. The blue lines in the picture show these tubes.

Sap goes to every part of the plant. It goes to the stems, branches, roots, buds, flowers, and seeds. Some of the food in the sap is used to make the plant grow. The stems and roots get longer and thicker, just as you put on more flesh and your bones get bigger. The buds get larger and make new leaves and flowers. Every part of the plant must have food or it cannot grow.

Not all of the food that a plant makes is used while the plant is growing. Much of the food is stored in the plant. The tubes carry food to the roots, and some of it is stored there. If much food is stored in the roots, they become very large. Carrots, beets, radishes, sweet potatoes, and parsnips have big roots full of stored food.

Some of the food is stored in seeds. The food that is in bean and corn seeds was made in the leaves of the plant and was carried to the seeds. So was the food in wheat and other grains. All seeds have food stored in them. When we eat seeds, we eat this stored food. When we eat peas, corn, beans, and nuts, we are eating food that was made in leaves and stored in seeds. When we eat carrots, turnips, beets, and radishes, we are eating food that was stored in the roots. When we eat celery and asparagus, we are eating food that was stored in the stems. When we eat lettuce and cabbage, we are eating food that was stored in the leaves. Cows, horses, sheep, pigs, chickens, and other animals eat the stored food in plants, too.



But the plants also use this stored food for themselves. Many kinds of trees lose their leaves in the fall, but the trees are not dead. Food has been stored in their roots, trunks, and branches. The stems and leaves of many plants die during the winter. But their roots are in the soil and do not freeze. In the spring, the stored food in the roots is used. New stems and leaves begin to grow.

Many green plants store food in bulbs and use it in the spring to grow. Lilies, daffodils, hyacinths, and tulips have bulbs, which are big storehouses for food.

Food stored in the seeds of plants is used by the seeds when they begin to grow. A seed is just a tiny plant with food and a covering around it. When the lima beans or radish seeds sprouted and showed their root hairs, you probably noticed that as each little plant grew larger, the seed became smaller. It became smaller because the food inside the seed was being used up by the young growing plant.

You have been learning about how a green plant makes food. The materials come into the plant through the root hairs and the leaves. The chlorophyll goes to work on these materials. The sun shining on the chlorophyll supplies the energy to make the chlorophyll do its work. The energy from the sun is changed to another form and stored in the food.

Without green plants you could not have anything to eat for your supper tonight. Do you see why? Suppose you were going to have roast lamb, potatoes, lima beans, lettuce and tomato salad, bread and butter, jelly, milk, and cake. Can you tell why each of these foods actually could not be on your table if green plants had not made food?

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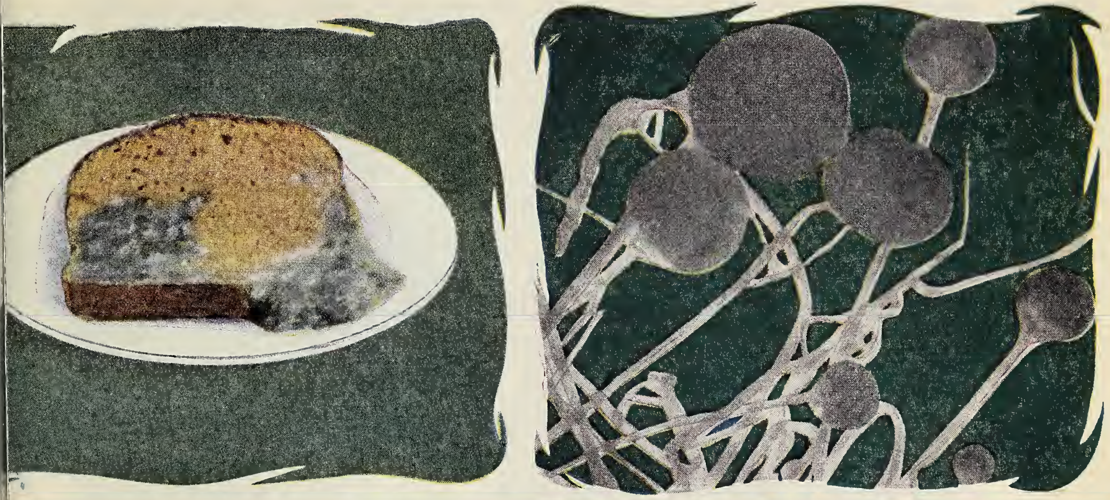
1. *A lion does not eat plants. It eats other animals. Does the lion depend on green plants for its food? Explain your answer.*
2. *What parts of plants have you eaten this week that had food stored in them?*
3. *How does food get from a green leaf to the stems, roots, buds, flowers, and seeds?*
4. *How does our supply of milk, meat, leather, and wood come from the food that was once in a plant?*
5. *What are two uses of the food stored in seeds?*

How do plants that are not green get food?

On page 24 you read that green plants sometimes help other plants by supplying them with food. Mushrooms, puffballs, and other fungi like the ones in the pictures on page 28 use other plants for food. These plants that are not green cannot change water and carbon dioxide into sugar and starch. They have none of the green chlorophyll that makes the



The picture on the left shows what will probably grow on the pieces of moist bread. The other picture shows you what bread mold looks like when you see it under the microscope. The little black balls contain the spores of the bread mold.

chemical change take place. So they have to use food that green plants have made.

You read about fungi in Unit One. Now suppose you grow some fungi. Bread mold is a fungus. It has no chlorophyll. Moisten a piece of bread, lay it in a dish, and shake a dusty cloth over the bread. Then cover the bread with another dish and leave it in a warm place for a few days. What do you see?

Look at the mold carefully. If you can see it under a microscope, it will look like the picture on this page. The bread mold sends little threads down into the bread. These threads are not roots. The threads soak up the food in the bread. This food was made by green wheat plants that grew in the soil, the air, and the sunshine. The food was stored in the seeds, or wheat grains. The grains were made into flour, and then the flour was made into bread. Mold will also grow on damp leather, meat, jelly, or almost any kind of food. Mold will even grow on live green plants and take in food that the plants are making.

If you have seen puffballs and other mushrooms growing in the soil, you know they are not green. They are growing up out of the soil, but they are not taking minerals from the soil and carbon dioxide from the air.

If you are ever walking in a damp, shady woods in the summer, you may find some of these strange white plants. They are called Indian pipes. As you can see, they have no chlorophyll. They get their food from the decayed materials in the soil.

They are just soaking in food from the bodies of plants and animals that have died and fallen to the ground. These bodies have decayed and become mixed with the soil. The sugar, starch, fat, and proteins that were in them went into the soil. Mushrooms and other plants that are not green just take in those foods that have already been made by green plants.

You almost never see mushrooms, puffballs, or other fungi growing on sandy beaches. They grow in fields and forests where there are plenty of plants and animals to die and become mixed with the soil.

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1. *Make a list of different things on which you have seen mold plants growing.*
2. *When mold grows on foods, the foods decay. Is decaying a chemical change? How can you tell?*
3. *Tell why mushrooms cannot make their own food. Then explain how the foods they use were really made in green leaves.*

QUESTIONS TO ANSWER

1. If you sprinkled water on the leaf of a plant, would the plant be able to use the water to make food? Why?
2. When plants are moved from one place to another, why should you be very careful not to damage the roots?
3. Why would we have no food if the sun did not supply energy?
4. Explain as carefully as you can how a plant makes food.
5. How do you think coal, oil, gas, and wood get the energy that is stored in them?
6. Should a tree be watered close to the trunk or several feet away from the trunk? Explain your answer.

THINGS TO DO

1. Sprout some different kinds of seeds on moist blotting paper and look for the root hairs.
2. Place the stems of different kinds of white flowers in colored water. Watch to see what happens. Find the tubes in the stems, leaves, and flowers.
3. Make a collection of plants that have no chlorophyll.
4. Bring samples of different materials on which mold is growing. Look at the mold with a magnifying glass.
5. Look at the branches of bushes, trees, and house plants to see how the leaves are placed so that each leaf will get plenty of sun. Draw a picture to show how the leaves grow.
6. Find out what a taproot is.

★ *In Unit Nine You Will Learn* ★

★ *How you can plan a garden* ★ *How we get the soil ready for planting* ★
★ *How we plant a garden* ★ *How we take care of growing plants* ★
★ *How plants are protected from their enemies* ★

★ UNIT 9 ★

How Can You Make a Garden?

"It will soon be time to start our garden," said Mr. Bates to his family one morning in early spring.

"You're joking," said Betty. "It's still cold outdoors."

"And the weatherman says we are going to have cold rain changing to snow," added Bill.

"I don't mean digging in the ground and planting seeds," explained their father. "There's more to gardening than that. Before we plant anything, we ought to plan our garden. We should decide what things we are going to grow, where we are going to plant them, and how much we want of each thing."

"Oh, I'd love to have a big flower garden," Betty said. "Then I could pick all the flowers I wanted."

Bill frowned. "Flowers are all right, I guess. But you can't eat them. I want to grow a lot of carrots and radishes and corn and beans."

"Now just a minute, children," laughed their mother. "We can have a flower garden and a vegetable garden, too. Let's look through these seed catalogues and pick out the things we want."

"I think we ought to read a book about gardening, too," Mr. Bates said. "I brought one home the other day. We can read it together."

In the gardening book, they found a list of rules to follow. They were called Guides for Good Gardening. Here they are.

GUIDES FOR GOOD GARDENING

1. Do not start a bigger garden than you can finish.
2. Do not plant too much of one thing.
3. Do not waste good seed on bad soil.
4. Do not use too much seed.
5. Do not let the weed crop win.
6. Do not let the insects eat your garden.

You can probably give some reasons for each of these rules right now. But as you study this unit, you will learn more about why they are good rules to follow. Perhaps you will want to copy them on a big piece of paper and hang them up in your room at home or at school.

How can you plan a garden?

Do you want to have a garden this spring? If you cannot have one at home, perhaps you can have one at school. You will find that gardening is a lot of fun. But you will enjoy your garden more if you can be proud of it. To have a good garden, you must think as well as work. You must plan your garden carefully. So start planning it early.

Are you going to have a vegetable garden or a flower garden or both? What kinds of vegetables or flowers do you want? How big will your garden be? Where will you have it? You should be able to answer all these questions before you plant anything.

The rule about not starting a bigger garden than you can finish is very important. If you have never made a garden before, start with a small one. You will probably be surprised at how much work you must do to take care of even a small garden. A good size to begin with is a garden ten or twelve feet long and four or five feet wide.

You should also follow the rule about not planting too much of one thing. When Mr. Bates read this rule to his family, he laughed.

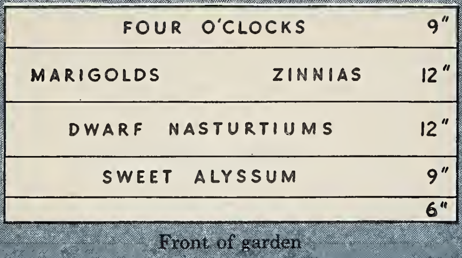
"What's funny about that?" asked Betty.

"Well," said her father, "I was just thinking of the first garden I ever had. I planted four long rows of radishes. When they were ready to eat, we had so many radishes we didn't know what to do with them. We had radishes for lunch and radishes for supper. We gave them away to our neighbors. I even tried to sell them, but everyone else must have planted a lot of radishes, too. So let's be careful not to plant too much of one thing in our garden."

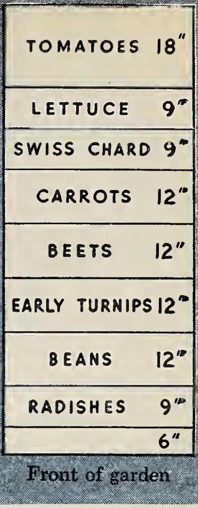
You know that green plants must have sunlight, air, and water to make their food. Keep this in mind when you pick out a spot for your garden. If you can, choose a place where the sun will shine on the plants all day. Be sure that trees, bushes, buildings, and fences will not shade your garden most of the time. Put tall plants on the north side of your garden and short plants on the south side. Then both will get plenty of sunlight.

The next rule, about not wasting good seed on bad soil, is also very important. So you should find out if the soil in the spot you choose for a garden is mostly clay, sand, or *loam*. Moist clay is sticky, and dry clay is almost as hard as rock. Sand is gritty. It falls apart even when it is wet. Loam is a mixture of sand and clay with some decayed material from plants and animals in it. This decayed material that is formed from the dead bodies of plants and animals is called *humus*. You can easily learn to tell one kind of soil from another.

This experiment shows you why you should know what kind of soil there is in your garden. Get three lamp chimneys and tie a piece of cloth over the bottom of each one. Also get a cupful of sand, a cupful of clay, and a cupful of loam. Be sure that each kind of soil is dry. If it is moist, dry it in an oven or other warm place. Pour the sand into one chimney, the clay into another chimney, and the loam into the third chimney. Press the soil down firmly in each chimney. Then set each chimney in an empty glass as shown in the picture.



FLOWER GARDEN



VEGETABLE GARDEN

Fill three other glasses with water. Give a glass of water to each of three members of your class. Have each one pour his glass of water into a chimney at the same time as the others do. Watch and see which kind of soil lets the water through first. Does the water run through the sand first? Then after a while does some of the water come through the loam? Does the clay hold the water so that it does not run through?

If soil is mostly sand or clay, plants cannot get the right amount of water. Sand drains so fast that roots cannot get enough water. Clay holds so much water that roots will rot. Moist clay sticks together tightly, and air cannot get into the soil. You can see why loam is the best soil for a garden. It holds water better than sand, and it drains better than clay.

When you decide what to grow and where to have your garden, draw a plan like the ones on this page. Use lines for the rows of different plants you are going to grow. The distance between the rows depends on how big the plants are when they are full-grown. You can find out many things about planning your garden in seed catalogues. Usually they tell just how far apart the rows of different plants should be.

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1. *Give several reasons why a garden should be planned.*
2. *Tell why each of the first three rules for gardening given on page 221 is important.*
3. *How would you pick out a good place for a garden?*
4. *For the experiment on pages 223-224, you must have dry soil. Tell why it is needed.*
5. *Why is loam better than either sand or clay for growing plants?*

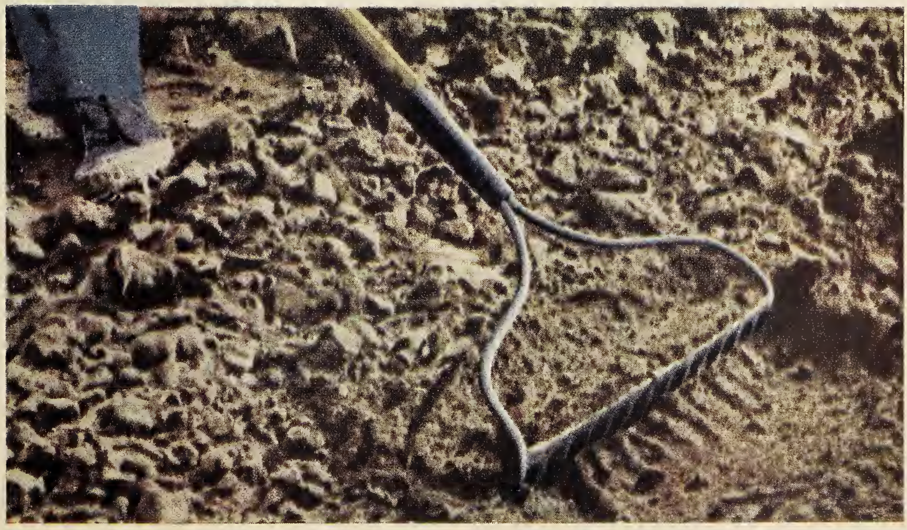
How do we get the soil ready for planting?

YOU CAN THINK of your garden as a little farm. A farmer does the same things you must do to make a garden. He must decide what things he will plant and where he will plant them. Then he must get the soil ready for planting. You can do this with your hands and a few tools. But a farmer needs machines and many different kinds of tools to help him with his work, because his fields are so much bigger than a garden.

To get the soil ready for planting, you must first loosen it and break it up. You cannot do this if the soil is too wet. If a lump of soil crumbles when you hit it, the soil is just right to work. But if it sticks together, it is too wet. You will have to wait until the soil is dry enough to work. Use a spade or a spading fork to dig into the soil and loosen it. Break up the lumps with a hoe or a rake. Then smooth the soil with a rake.

A farmer uses a plow to loosen the soil and break it into big chunks. These must be broken up into smaller pieces, and then the soil must be smoothed. To do this, a farmer uses a tool called a *harrow*. This has sharp disks or long, pointed teeth that cut into the soil and break it up. Sometimes a harrow is pulled behind a plow. Then the soil is plowed and harrowed at the same time.

Loosening and breaking up the soil make it easier to plant seeds down where they start growing best. And



The man in the picture on the left is plowing. In the other picture, a farmer is using a disk harrow to break up the big lumps of soil.

the soil can help keep the water that plants need. Water easily soaks into the ground when the soil is loosened and broken up. But if the ground is hard, much water runs off instead of soaking in.

While you are getting the soil ready for planting, remember the rule about not wasting good seed on bad soil. If the soil is poor, you can do several things to improve it. Loam is the best soil for your garden. You can make the soil more like loam. If the soil is too sandy, mix some clay and humus with it. If it contains too much clay, mix in some sand or ashes and some decayed material. Seed stores also sell a material called peat moss which is made of decayed plant materials. It can be used to make sandy soils or clay soils better for growing plants.

Have you ever heard of sour soil? It is soil with too much acid. Many plants will not grow well in sour, or acid, soil. In Unit Five you learned how to use blue litmus paper to test for acid. Put some moist soil from your garden on some blue litmus paper. If the paper turns red, the soil has acid in it. To make it less acid, put lime or ground-up limestone on the soil.

The soil may need fertilizer, too. You know that plants use dissolved minerals in the soil to make food. Plants take minerals from the soil all the time they are growing. But if the soil hasn't the right minerals in it, plants will not grow properly. Then we have to find some way to put the minerals into the soil.

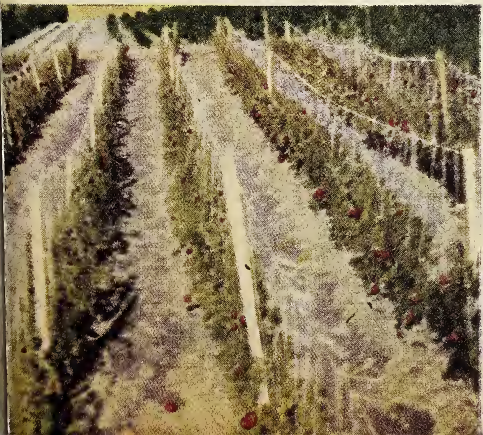
If we let plants die and decay, the minerals in them will slowly soak into the ground. Then other plants can use them to make food. But in a garden or on a farm we harvest the plants and take them away. Most of the minerals do not get back into the soil. Some plants, like corn or potatoes, use up the minerals very fast. When these plants are grown in the same soil for several years, there are not enough minerals left to raise a good crop. Then a fresh supply of minerals must be put back into the soil. One way to do this is to use fertilizer.

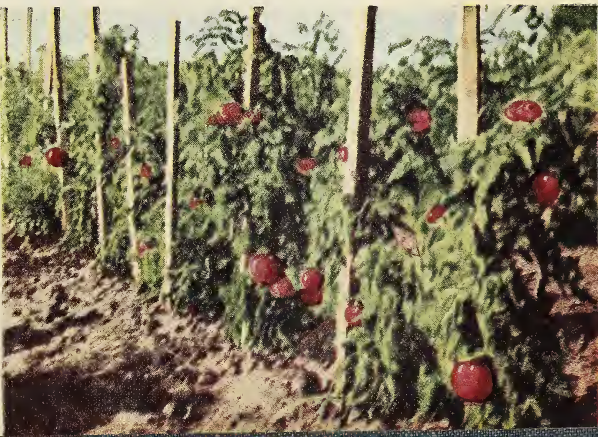
You can do an experiment to see what happens when soil is fertilized. Fill two flowerpots with soil that has been used to grow plants for a long time. Plant the same kind of seeds in each pot. Give them both the same amount of water at the same times. Set them side by side in a place where they will get the same amount of sunlight. When the plants come up above the soil, put some fertilizer in one pot. You can get the right kind of fertilizer from a florist. Follow the directions carefully so that you use just the right amount of fertilizer. Then watch the plants in the two pots to see which ones grow better.

Fertilizer contains the minerals that plants need. By doing many experiments, scientists have found out what elements in these minerals are used by plants. Without nitrogen, a plant will not have healthy, green leaves. Phosphorus helps the roots grow and makes plants develop faster. Potassium also helps roots grow. And it makes the stems strong and helps the seeds form. A plant must have magnesium to make chlorophyll. Without an element called boron, a plant may have brownish flowers and stems. If a plant cannot get manganese, its leaves may turn yellow. Plants also need calcium, sulphur, iron, copper, zinc, and possibly a few other elements.

The pictures on this page show you that plants need these elements. The tomatoes in the left-hand picture were grown without copper, zinc, manganese, or boron. The ones on the right were fertilized with these four elements. Which ones look like better tomato plants?

Scientists know how to test soil and find out what elements it contains. They can tell what elements should be added to make plants grow better. At agricultural colleges and at governmental farms or stations, scientists





test soil. A farmer can have his soil tested at any one of these places. Or he can buy a set of chemicals and test the soil himself.

Fertilizer puts minerals back into the soil, but the right kind and amount must be used. The wrong kind or too much of the right kind may injure plants instead of helping them. Before you put any fertilizer on the soil in your garden, talk with someone who knows about the different kinds. Find out what kind to use and then follow the directions carefully. Spread the fertilizer evenly over the soil. Then mix it into the soil with a hoe or a rake. If you sprinkle the ground with water, it will help the minerals dissolve.

There are many different kinds of fertilizer used to make plants grow better. One kind is animal manure. It is a good fertilizer, because it contains nitrogen, phosphorus, and potassium. Usually it contains dead plant material, too. And so it adds humus to the soil. In the fall, the manure is often put on gardens and farm fields or around trees and bushes. During the fall and winter, it decays. Rain and melting snow dissolve the minerals. They soak down into the soil where plants can use them.

When the ground is spaded in the spring, the manure can be turned under. To do this, just turn the spadeful of earth over when it is put back into the hole. Then the manure will be in the soil.

Farmers have another way of putting minerals back into the soil. If corn or certain other crops are grown in the same field year after year, the crops become poorer and poorer. Minerals are taken from the soil and not put back. Corn takes a lot of nitrogen from the soil. But clover, alfalfa, soybeans, and cowpeas put nitrogen back into the soil. So farmers plant corn in a field for a year or two. Then they plant clover, alfalfa, soybeans, or cowpeas in the same field for a year or two. This keeps the soil from losing all of its nitrogen.

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1. *Give two reasons for loosening and breaking up soil.*
2. *If the soil in your garden is too sandy, what can you do to improve it?*
3. *Why is lime or ground-up limestone sometimes put on soil?*
4. *When do plants take minerals from the soil? When do they put minerals back into the soil?*
5. *Before putting fertilizer on your garden, what should you find out?*
6. *How are a garden and a farm alike? How are they different?*

Marjorie is using a garden line to guide her in making a straight furrow. Jane is planting beet seeds in a furrow.

How do we plant a garden?

Now comes the fun of planting your garden! Everything else is done. You have decided what to grow, and you have drawn a plan of your garden. The soil is ready for planting. The next thing to do is to follow your plan in laying out the garden.

Use a string to make straight rows. The string should be a little longer than one row. Tie a stake to each end of the string. Push the stakes in the ground so that the string is tight and right over where you want a row of plants. Then make a furrow directly under the string. To make a furrow, you can use the end of a stick or the handle of your hoe or your rake, as the girl in the picture is doing.

Look at the different kinds of seeds you are going to plant. Some are probably larger than others. Large seeds should be planted deeper and farther apart than small seeds. The depth that the furrow should be depends on the size of the seeds.

For little seeds, such as carrots and lettuce, make a furrow about one-fourth inch deep. Remember the rule about not using too much seed. Take a few seeds at a time and scatter them evenly in the furrow. Cover them with about one-fourth inch of fine soil. Press the soil down hard with your hand all along the row. You do this to make sure that moist soil touches the seeds.

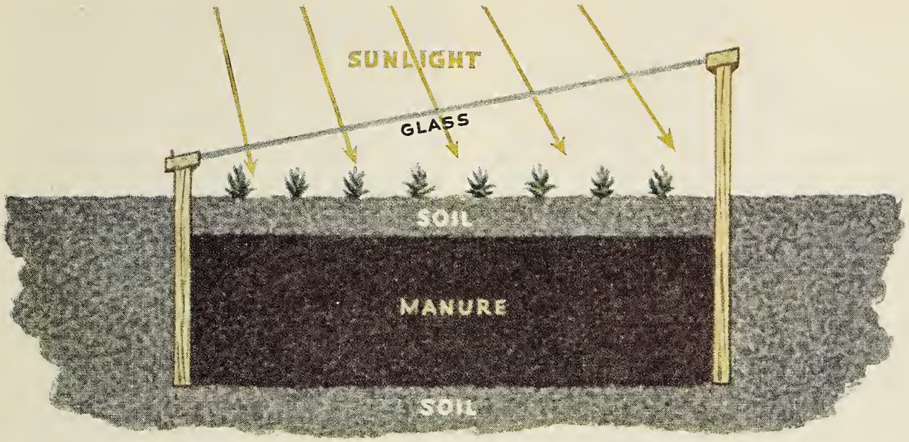
For medium-sized seeds, such as beets and radishes, make a furrow about one inch deep. Scatter the seeds evenly in the furrow and then cover them with one-half inch of fine soil. Press down hard on the soil with your hand all along the row.

For big seeds, such as beans and peas, make a furrow about two inches deep. Put the seeds about one and one-half inches apart in the furrow. Cover the seeds with a little more than an inch of soil. Press the soil down firmly with your hand.

You should also know when to plant different kinds of seeds. Read the directions in seed catalogues or on packages of seeds to find the best time for planting. In the early spring while it is still cool outdoors, you can plant carrots, lettuce, beets, radishes, and spinach. The seeds will sprout and grow. But you should not plant beans, peas, corn, cucumbers, or squash while it is cool. The seeds of these vegetables will not sprout until the weather is warm.

Some vegetables and many flowers take a long time to grow. They should be started early, but their seeds will not sprout until it is warm. If you wait for warm weather to plant tomatoes, peppers, cabbages, and eggplant, the vegetables will not be ready to eat before cold weather comes again in the fall. Do you know how we start plants like these growing early? We make a warm place for the seeds to sprout.

Have you ever seen a *greenhouse?* It is a building with a roof and walls made of glass. When the sun shines, its heat warms the soil inside where plants are growing. The soil warms the air in the greenhouse, and the glass keeps the warm air from getting out. It also keeps cold air, snow, and rain from getting in. At night or on cloudy days, a furnace heats the green-



When the days begin to get warm, the glass on the hotbed should be raised a little during the middle of the day. This gives the plants air and keeps them from getting too warm.

house. Even in winter, vegetables and flowers can be grown.

Plants can be started early in a greenhouse. You can buy these plants to put in your garden, or you can grow them yourself. You do not need a greenhouse to do this, but you can use something like it. Look at the picture on this page. It shows how a *hotbed* is made. A frame is set in a hole about two feet deep. The frame should be lower on the south side than on the north. Inside the frame, there is a layer of manure about eighteen inches deep. A layer of good soil about six inches deep is put over this. After seeds are planted in the soil, a glass cover like a big window is set on top of the frame.

The sun warms the soil in the hotbed, and the soil warms the air. The glass cover keeps the warm air in and the cold air out. The manure also helps warm the soil. You know that manure decays. As it decays, a chemical change takes place. This produces heat, which warms the soil above the manure. The seeds sprout in the warm soil, and the plants begin to grow.

Another way you can get plants started early is to use a *cold frame.* This looks like a hotbed, but it has no layer of manure under the soil. Only the sun warms the soil in a cold frame. So the growing plants are not kept as warm as they are in a hotbed.

Plants should be kept in a cold frame or a hotbed until there is no danger of freezing weather. Then the little plants can safely be taken out and set in the soil of your garden.

This is called *transplanting*. When you transplant, take up some soil along with the roots of each plant. Then make a hole in the soil of your garden. Be sure that the hole is big enough to hold the roots of one little plant. With your fingers, pack the soil down firmly around the roots but be careful not to injure them.

It is fun to plant a garden, and it is fun to watch it grow. But probably the most fun comes when you pick the vegetables and flowers. You may want to know how much of each thing you raise. If you do, you can keep a record of all the things you pick in your garden. Write down the day of the month when you pick each thing.

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1. *Would you plant peas, carrots, and radishes in the same furrow? Why?*
2. *If you plant cucumbers, lettuce, beans, corn, and beets in the early spring, which ones will probably come up? Which ones may not?*
3. *How are plants started early while it is still cool outdoors? Name three ways and tell how each one works.*
4. *Tell how to transplant cabbage plants or tomato plants.*

How do we take care of growing plants?

FOR SEVERAL DAYS after their garden was planted, Bill and Betty went to look at it. Nothing seemed to happen. So they stopped going to see it every day. Then one afternoon Bill came running toward the house. He was very excited.

"It's up!" he shouted.

"What's up?" asked Betty.

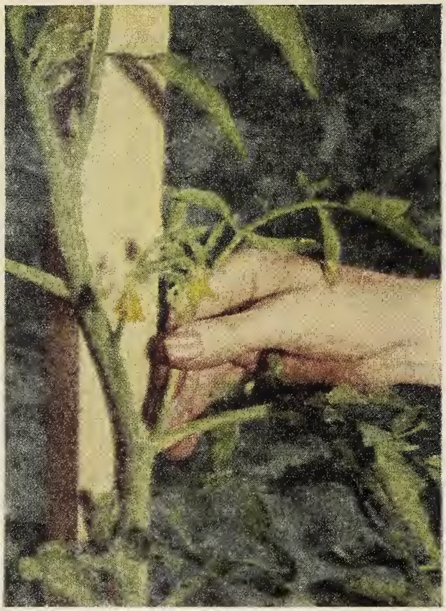
"Our garden," answered Bill. "It's really growing. You can see the little plants. Come and look."

You will probably be excited, too, when you see the first plants coming up in your garden. You planted the seeds yourself. They sprouted in the warm, moist soil. And they are growing. From now on, you will be busy taking care of the growing plants.

When you planted your garden, you left spaces between the rows. If the rows are far enough apart, the plants in one row will not keep plants in another row from getting enough sunlight, water, and minerals. But if plants in the same row are too close together, they will not grow into healthy plants. None of them can get enough sunlight, water, and minerals.

When the plants have come up several inches above the ground, you may find that there are too many of them in one row. So you must *thin* the plants as soon as they are big enough to handle. To do this, you pull out some of the plants and leave more room between the others. You may not like to pull out plants that are growing. But you know why you must do it. You do it to give the other plants room to grow. The picture on this page shows how far apart beets should be after they have been thinned. Pulling out some will make the ones that are left grow bigger.

Have you ever seen men cutting branches from fruit trees in an orchard? This is called *pruning* the trees. Some of the smaller branches are cut off so that the other branches can get more sunlight, food, and water. Pruning helps the trees grow bigger and better fruit. The roots take in only so much water and minerals, and the leaves make only so much food. When the smaller



Someone is removing a sucker from a tomato plant in the picture on the left. The other picture shows a tomato plant that has been pruned so that there is just one main stem.

branches and their buds are cut off, those that are left get more food.

At a fair or a garden show, you can see big, beautiful flowers, fruits, and vegetables. Many of them are grown by pruning the plants. All the buds except one at the end of the stem are cut off. Then this bud grows big because it gets all the food. You may not win a prize at a fair or garden show with your flowers or vegetables. But you can make some of your plants grow better by pruning them.

If you prune tomato plants, you will get bigger tomatoes. You will see that little shoots, or *suckers,* grow out at the place where the big leaves come from the stem. Pinch these shoots off with your fingers or cut them off before they grow very big. Every few days, look at the plants and remove any new suckers.

While you are down on your knees thinning or pruning the plants in your garden, you can do something else. Do you remember the rule about not letting the weed crop win? Weeds are plants we do not want. They keep the plants we do want from getting enough sunlight, water, and minerals. So pull out the weeds as you thin or prune the plants in your garden.

Weeding and cultivating will keep you busy when your garden starts to grow. The boy who is hoeing is doing it correctly. He is pulling the hoe toward himself.

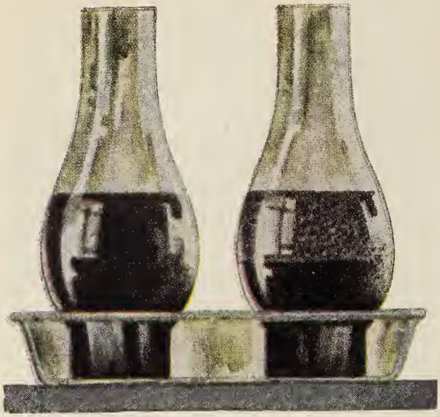
Be sure to pull out the roots of weeds like crab grass and pigweed. Also get the weeds out of your garden before they can make seeds.

You must keep the soil in your garden loose all the time the plants are growing. This is called *cultivating* the soil. You can use a hoe to cultivate your garden. Go down along each row, loosening the soil. Do not dig too deep, or you may chop off the roots of your plants. At the same time, chop out the weeds or uproot them. Getting the weeds out is one reason for cultivating a garden.

Another reason for loosening the soil is to let air get down to the roots of growing plants. Plants need oxygen from the air for the same reason that animals need it. They use the oxygen from the air to get energy from their food.

There is a third reason for cultivating the soil in your garden. All the time plants are growing, they must have water. You know that loosening the soil makes it easier for water to soak in. It also helps to keep water from getting out after it has soaked in. An experiment will show how cultivating your garden helps to keep the soil from drying out.

Dig some soil from your garden and sift it through a flour sieve. Set



two lamp chimneys in a flat pan. Fill one of the chimneys half full of fine soil. Pack the soil down firmly as you put it in. Now put fine soil in the other chimney until it is one-third full. Pack the soil down firmly. Then add enough loose soil to fill the chimney half full. The soil in the two chimneys is just the same. But the soil at the top of one is much looser than the soil at the top of the other.

Pour water into the flat pan so that it can get into the soil in the chimneys. Watch the water. In which chimney does the water get to the top of the soil first? As the water gets to the top, it evaporates into the air. Watch the soil in the two chimneys for several days. In which chimney does the soil dry out first?

The loose soil in one chimney holds the water longer than the tightly packed soil in the other chimney. Cultivating loosens the soil near the top in your garden. The experiment shows you that this keeps the soil from drying out so fast.

If the weather is very dry or if the soil is very sandy, you will probably have to water your garden. When you do, give it a good soaking. Then you will not need to water more than once a week. Water your garden in the evening. Then the water can soak down to the roots before the heat of the sun makes much of the water evaporate. Keep the soil in your garden loose so that the water will soak into the ground and stay there.

Many parts of our country get enough rain and snow to supply water for gardens and farms. But the water may come at a time of the year when plants are not growing. By cultivating the soil, we can keep much of this water in the ground. Then plants can use it when they grow.

But some parts of our country do not get enough rain or snow to supply water for gardens and farms. Before plants can be raised, water must be brought to the land. Much land in the western part of our country is *irrigated* by water from mountain streams. The streams get the water from rain or snow. Dams hold back the streams and form large reservoirs. Water stored in the reservoirs can be used as it is needed. It flows many miles through ditches and pipes to the dry land. In some places, fields are irrigated during dry weather by water from springs.

This man is irrigating his celery field. The water is coming up through a pipe from an underground spring.

Plants must have enough water to make food and grow. But do you know what happens when plants get too much water? You can do an experiment to find out. Get two flowerpots of the same size and material. Each flowerpot should have a hole in the bottom. Cover these holes with small stones or pieces of a broken flowerpot. Then get two plants of the same kind that are about the same size. Put one plant in each flowerpot and press soil around the roots.

Set the plants side by side in a place where they can get the same amount of sunlight. Give each plant the same amount of water. After the plants are growing well, plug up the hole in one of the flowerpots. Keep on giving each plant the same amount of water every day for several weeks. Watch the plants carefully to see how they grow. Which plant grows better? Is it the one in the pot with the open hole? Does water stand in the pot with the plugged hole? Does water drain out of the other pot?

Now unplug the hole in the flowerpot. What happens to the water? If the plant is not dead, it will begin to

grow again. Watch it for several days to see what happens.

The experiment shows that too much water is just as bad for a plant as not enough water. You know that plants need oxygen to use their food. When the soil is full of water, air cannot get to the roots. The roots rot, and the plants soon die.

Sometimes water stands on the soil after a heavy rain. If it stands there for long, the growing plants will die. So we have to find a way to get rid of the water. In a garden, a little ditch will usually carry the water away. On farms, ditches are also used to drain low, wet land. But when water runs off into ditches, some of the good soil is usually carried along with it. Ditches also take up room that could be used for raising crops. Weeds often start growing in ditches and then spread to the fields.

The picture on this page shows a better way to get rid of too much water on the soil. A farmer first digs a ditch about three feet deep. Then he lays short pieces of pipe in the ditch. The pipe is made of baked clay, and it is called *tile*. The pieces of tile are laid so that they make a long tube, but a space is left between the pieces. The ditch is filled in, and the tube is covered up. Water soaks slowly down through the soil and into the tube at every space between pieces. The tube slopes a little so that the water will run off into a ditch or pond.

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1. *Why may a row of plants in your garden have to be thinned?*
2. *Tell why you should prune tomato plants. How would you do it?*
3. *Name four things that growing plants need. How can you help the plants in your garden get them?*
4. *What are three reasons for cultivating the soil? Explain why each one is important.*
5. *Why is too much water as bad for plants as not enough water?*
6. *How do farmers keep too much water from standing on the soil?*

How are plants protected from their enemies?

In your garden, a war is going on. No shots are fired, and no bombs are dropped. But it is a war just the same. And it is being fought in gardens and on farms everywhere. This is the war against the enemies of our plants. Without help, the plants would soon lose the war, for they are not very good fighters. Let us see how plants are protected from their enemies.

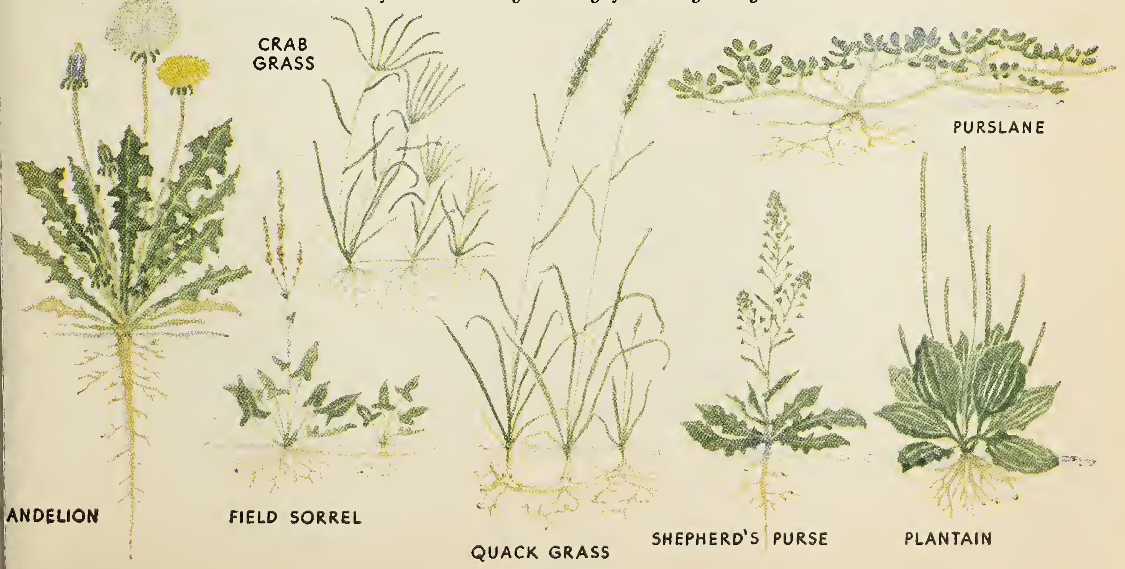
Weeds come up in your garden even though you do not plant their seeds. The seeds were in the soil all winter. When the soil became warm and moist in the spring, the seeds sprouted and the weeds began to grow. These weeds are enemies of our plants. They keep the plants from getting enough sunlight, water, and minerals.

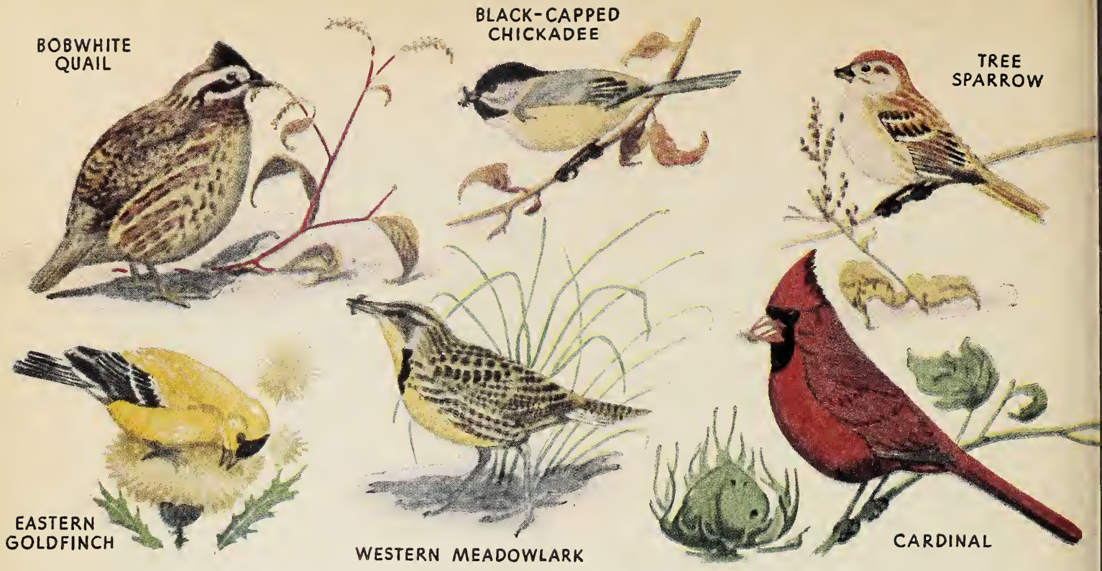
Look at some weeds, and you can see how many seeds they make. Also notice how easily the seeds are scattered. Do you see why weeds should be killed before they can make seeds? After the seeds are made, the wind may carry them for miles. No wonder weeds spread so fast and come up where we do not want them!

Crab grass is a weed that is hard to get rid of. It grows from seeds every year. You can kill crab grass by keeping it from making seeds. Dig it out by hand while it is very young. This takes time, but it is not hard to do because the roots are short. Chickweed and dandelions make seeds all summer long. Pull them up before the seeds are ripe.

The roots of some weeds stay in the ground year after year. New weeds grow from the roots. If the tops of the weeds are cut off or broken off, new shoots will soon come up. To get rid of such weeds, pull them out by the roots and then burn them.

Here are some of the weeds you may find in your garden.





Learn to recognize as many of these birds as you can. They are among our best helpers.

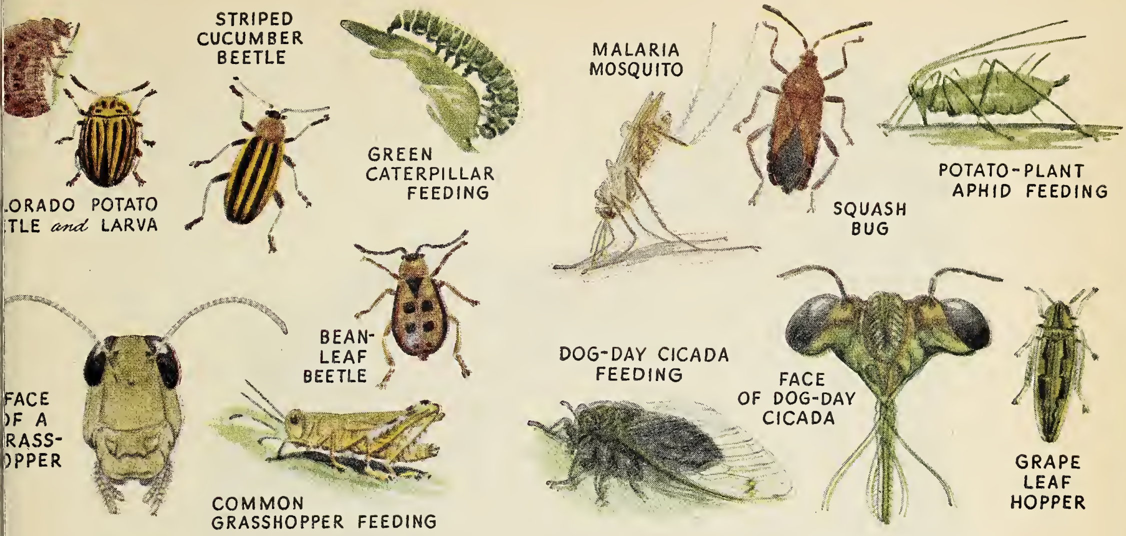
Remember the rule about not letting the weed crop win. You know that cultivating the soil helps kill weeds. But you will have to get down on your knees and pull some weeds out by hand. Farmers sometimes use strong chemicals to kill weeds in their fields.

There is another way of getting rid of weeds. We seldom think about it, but it is very important. If birds did not help protect our plants, the weed crop would surely win. Scientists have found out what birds eat by looking into the stomachs of dead birds. In the stomach of one quail, they counted 300 smartweed seeds, 500 sorrel-grass seeds, 700 mercury-weed seeds, and 1000 ragweed seeds.

Of course, these were not all the weed seeds that the quail ate in one day. Only the undigested seeds could be counted. In one day, a quail can eat many more seeds. Every year birds eat millions of pounds of weed seeds that otherwise might destroy valuable crops in fields and gardens.

Birds help protect our plants in another way, too. In Unit One, you learned that insects are the most dangerous enemies of our plants. They eat the leaves, stems, roots, flowers, and fruits. Each kind of plant has at least one kind of insect enemy. Birds are the greatest protectors of plants, because they eat huge numbers of insects.

One scientist counted more than 1000 ants in the stomach of a flicker. The stomach of a nighthawk had fifty different kinds of insects in it. Every day, birds eat millions and millions of insects. If all these insects lived, they would soon destroy all the plants that we grow in our gardens and on our farms.



On the left are some chewing insects. The head of a grasshopper shows what the mouths of chewing insects are like. On the right are sucking insects. The head of the cicada shows the long tube with which sucking insects suck the sap from plants.

Birds are a great help in the war on the insect enemies of plants. But we must kill harmful insects, too. Scientists supply us with weapons for fighting the insects that eat our plants. They study the harmful insects to find out where they live, what they eat, where they lay their eggs, how they change as they grow, and many other things about them. We can use what scientists discover about insects to protect our plants.

You can study some insects to find out how they eat. Get a weed or any plant that has aphids on it. You know that aphids are also called plant lice, or ant cows. Look at one of the aphids with a magnifying glass to see how it eats. If you look closely, you will see a little tube making a hole in the leaf or stem of the plant. With this tube, an aphid sucks sap from a plant, just as you suck a drink through a straw. Insects that eat in this way are called *sucking insects.*

Many insects get their food in a different way. If you watch a grasshopper when it is eating, you will see it bite a piece out of a leaf with its jaws. They move from side to side as it chews the leaf. Insects that eat in this way are called *chewing insects.*

Scientists have found out how to kill many kinds of harmful insects by poisoning them. There are many different kinds of insect poisons. Some of them are liquids that can be sprayed on the plants. Others are powders that are dusted on plants or first mixed with water and then

Are these tent caterpillars a kind of chewing insect, or a kind of sucking insect?

sprayed on. Just what kind of poison we use depends on the way the insects we want to kill get their food.

We kill chewing insects by putting poison on the parts of plants that they eat. The insects take the poison into their bodies along with their food. So this kind of poison is called a *stomach poison.* Two chemicals often used as stomach poisons are lead arsenate and calcium arsenate. They are powders that can be dusted on plants or mixed with water and sprayed on. Use a stomach poison to kill chewing insects. Some of these are the cabbage worm, the potato beetle, the grasshopper, and the tent caterpillar that makes a tentlike web in trees and shrubs.

We cannot use a stomach poison to kill sucking insects. They get their food inside plants where poison cannot reach it. But we can kill them by putting on the plants a kind of poison that will touch their bodies. This poison will get into the breathing holes of the insects and kill them. Because this kind of poison must touch the insects to kill them, it is known as a *contact poison.* Tobacco extract is a good contact poison.

To kill aphids, use a contact poison. Follow the directions carefully. Spray or dust the poison on the plants where the aphids are feeding. You will be surprised to find how quickly they will be killed. Other sucking insects can be killed with contact poisons. One of these is the cucumber beetle that feeds on cucumber, squash, and melon vines. Another is the stinkbug often found on berry plants.

Not many years ago, scientists discovered a poison that kills many kinds of insects. This poison is called *DDT*. It kills both chewing and sucking insects. DDT is very good to use on the cabbage worm and the potato beetle. It is also very good for killing flies, mosquitoes, and some other insects that are pests in the house.

Unfortunately, DDT will not kill every kind of chewing and sucking insect. And it does not kill all the insects that are sometimes pests in the house. Also, a few plants like tomatoes and beans may be injured by it.

All insect poisons must be used with care. Some of them, such as lead arsenate, tobacco extract, and DDT are also poisonous to people, pets, and farm animals. Use these poisons only on parts of a plant that are not used for food. Or use them when the plants are just beginning to grow.

One of the best and safest poisons to use in killing insects is *rotenone*. It will kill both sucking insects and chewing insects, because it is a contact poison as well as a stomach poison. It is not poisonous to people, pets, or farm animals.

An insect larva called the cutworm is one of the worst enemies of young plants. It works at night, and it eats right through stems near the ground. Cutworms often kill young plants the first night after they have been transplanted. You may lose all of your tomato plants in this way. Cutworms also eat the shoots of sweet corn just after they push above the soil.

You can use a stomach poison to kill cutworms. Put some poison bait on the soil before young plants are transplanted or before the shoots come up. The poison bait is made by mixing a poison with bran and water.

Sally is spraying her zinnias with a stomach poison. How could she tell that she should use this kind of poison?

Another way to protect plants against cutworms is to put a piece of stiff paper around the stems. The paper should be about one inch above the soil and go down about two inches under the soil. This keeps the cutworms from getting to the stems.

Plants have other enemies besides weeds and insects. In Unit One you learned that tiny fungi cause potato blight, corn smut, apple rust, and wheat rust. The fungi grow on the green plants and use them for food. Then the green plants are spoiled so that we cannot use them ourselves. Scientists have found ways to protect green plants from some of these fungi. A spray or powder made from sulphur is one of the commonest chemicals used to kill fungi. Many fungi are hard to control, and they do a great deal of damage to our crops.

1. *Why are weeds harmful to the plants we grow? Give some ways of getting rid of weeds.*
2. *What things must scientists find out about insects before they can fight them? Why?*
3. *Give two different ways that insects get their food from plants.*
4. *Would you use a contact poison or a stomach poison to kill each of these insects?*
   Cucumber beetle   Cabbage worm   Potato beetle   Aphid
5. *Why is rotenone a good poison for killing insects on plants?*
6. *Tell how birds help protect plants from their enemies.*

QUESTIONS TO ANSWER

1. If you made a garden at home or at school, tell how this unit helped you get it ready and then take care of it.

2. What are the most important crops grown in your community or in your province?

3. How do farmers in your community or province kill insects that eat their crops?

4. If scientists did not help gardeners and farmers, how would gardening and farming be different?

5. When the Indians planted corn, they sometimes put a dead fish in the ground with the seeds. Do you think this would help the corn grow? Explain your answer.

6. Look around your community for examples of clay soil and sandy soil. Do many plants grow in these places?

7. Would you plant corn on the north or south side of your garden? Why?

THINGS TO DO

1. Find out how plants can be grown without soil.

2. Visit a greenhouse and learn how plants are grown there.

3. Learn the names of the weeds and insects that are the commonest enemies of the plants in your community.

4. If you can, visit an up-to-date farm or an experimental farm. Find out what crops are grown and what kinds of farm machines are used.

5. Read newspapers and magazines for more information about weed control, insect poisons, gardening, and irrigation. Cut out the articles and bring them to school.

6. Find out more about the insect poison called DDT.

7. Study a map that shows the amount of rainfall in all parts of Canada. What parts need to be irrigated? What parts have enough rainfall to grow crops?

8. Learn the names of the most helpful birds in your community.

9. Collect pictures of farm machines and find out how each machine is used.

10. Find out more about fungi that are enemies of the plants we grow in our gardens and on our farms.

11. Find out about the weed killer called 2, 4 D.

SCIENCE WORDS

CAN YOU SAY the word *element?* Do you know what it means? You can easily find out. Look in the list of science words that begins on this page. The word *element* is on page 247.

Notice that each word in the list is printed twice. The second time shows you how to say the word. Some of the letters have marks over them. The mark tells how the letter sounds. Look in the list below to see how each letter sounds.

Now look at the word *backfire* near the bottom of this page. The slanting mark **′** after *bak* is bigger than the slanting mark ′ after *fīr*. So you say *bak* with more force than *fīr*.

a	hat, cap	ėr	term, learn	ô	order, all	ə	represents:
ā	age, face	i	it, pin	u	cup, butter	a	in about
ã	care, air	ī	ice, five	u̇	full, put	e	in taken
ä	father, far	o	hot, rock	ü	rule, move	i	in pencil
e	let, best	ō	open, go	ū	use, music	o	in lemon
ē	equal, see					u	in circus

acid (as′id), a sour material that turns blue litmus paper red.

aphid (ā′fid), a very small insect that lives by sucking the sap of plants; a plant louse.

automatic stoker (ô′tə mat′ik stōk′ər), a machine to control the amount of coal supplied to a fire.

backfire (bak′fīr′), a controlled fire set to stop a forest fire or grass fire by burning off the space ahead of the fire.

bacteria (bak tēr′i ə), very, very tiny plants that often cause diseases.

bakelite (bā′kə līt), the name for a kind of plastic.

ball bearing (bôl bãr′ing), a bearing in which parts turn on a number of loose metal balls.

battery (bat′ər i), a set of two or more electric cells connected to produce electric current.

bearing (bãr′ing), a part of a machine on which another part turns or slides.

beebread (bē′bred′), a brownish, bitter substance made from pollen and honey. It is used by bees for food.

belt (belt), a band put around two wheels so that one wheel will turn the other.

beriberi (ber′i ber′i), a disease caused by lack of vitamin B_1. It affects the nerves and causes loss of weight.

block and tack le (blok ənd tak′əl), two pulley blocks and a rope used together to lift or pull something.

boil ing point (boil′ing point), the temperature at which a liquid boils.

car bo hy drate (kär′bō hī′drāt), a compound of carbon, hydrogen, and oxygen.

car bon tet ra chlo ride (kär′bən tet′rə klō′rīd), a colorless, noninflammable liquid that changes to a heavy gas when heated.

cell (sel), 1. a container that holds materials for producing electric current by a chemical change. 2. the smallest part of a living thing. All animals and plants are made of cells.

cel lo phane (sel′ə fān), the name of a thin, clear plastic.

cel lu loid (sel′ū loid), the name of a hard, inflammable plastic.

char ac ter is tic (kar′ik tər is′tik), a special feature of a material that makes it different from other materials.

chem i cal change (kem′i kəl chānj), a change in a material that makes a new material with different characteristics.

chew ing in sect (chü′ing in′sekt), an insect that gets food by biting and chewing a plant with its jaws.

chlo ro phyll (klō′rə fil), a green material in leaves that is needed by a plant to make food.

cold frame (kōld frām), a glass-covered frame set in the ground. It is used to protect and warm young plants.

col o ny (kol′ə ni), a group of animals or plants living or growing together.

com bine (kəm bīn′), join together to make a compound.

com bus ti ble (kəm bus′ti bəl), able to catch fire and burn.

com pound (kom′pound), a material made of two or more different elements joined together.

com press (kəm pres′), squeeze together.

con ser va tion (kon′sər vā′shən), protection and wise use of wild life, etc.

con tact poi son (kon′takt poi′zən), a poison that kills insects when it touches their bodies.

con tract (kən trakt′), get smaller.

cul ti vate (kul′ti vāt), loosen the soil around growing plants.

curd (kėrd), the thick part of milk that separates from the watery part, or whey, when milk sours.

drone (drōn), a male bee.

e las tic (i las′tik), able to spring back to its original size or shape after being stretched or squeezed.

el e ment (el′i mənt), the simplest kind of material from which other materials are made. Scientists have discovered 96 different elements.

en rich (en rich′), make richer. Adding vitamins and minerals enriches food.

ex pand (eks pand′), get larger.

Fahr en heit (far′ən hīt or fär′ən hīt), according to the kind of thermometer that we ordinarily use for measuring temperature. Water freezes at 32 degrees Fahrenheit, and it boils at 212 degrees Fahrenheit.

fire lane (fīr lān), a wide path cut or plowed to remove materials that will burn. Fire lanes are used to prevent the spread of forest fires and grass fires.

fire proof (fīr′prüf′), that will not burn; almost impossible to burn.

fixed pul ley (fikst pu̇l′i), a pulley that is fastened to a support.

fric tion (frik′shən), rubbing of one thing against another.

ful crum (ful′krəm), the point on which a lever turns or is supported in moving a weight.

fun gus, plural **fun gi** (fung′gəs, fun′jī), a kind of plant that has no chlorophyll. It cannot make food for itself.

gear wheel (gēr′hwēl′), or gear, a wheel with teeth and notches on it. The teeth prevent slipping when one gearwheel turns another.

gen er a tor (jen′ər ā′tər), a machine for making electric current. It is run by steam, wind, water, or other power.

grav i ty (grav′i ti), the force that pulls all things toward the centre of the earth.

har row (har′ō), a heavy frame with long teeth or sharp disks that break up the soil. Farmers use a harrow after plowing.

hot bed (hot′bed′), a glass-covered frame under which young plants are started. Extra heat is given off by a layer of manure under the soil.

hu mus (hū′məs), decayed materials in soil.

hur ri cane (hėr′i kān), a storm with very strong winds and usually with heavy rain. The wind in a hurricane blows from 70 to 100 miles an hour.

in clined plane (in klīnd′ plān), a simple machine made by sloping or slanting a board or other flat surface.

ir ra di ate (i rā′di āt), add vitamin D to certain foods.

ir ri gate (ir′i gāt), supply land with water by using ditches.

kin dling tem per a ture (kin′dling tem′pər ə chər), the temperature at which a combustible material will catch fire and start to burn.

lar va, plural **lar vae** (lär′və, lär′vē), the second part in the life of some insects and other animals. The larva hatches from the egg. The tadpoles of frogs, toads, and other amphibians are also called larvae.

lev er (lev′ər or lē′vər), a simple machine for lifting or moving a weight by pushing down or pulling up on a bar.

lit mus pa per (lit′məs pā′pər), a special blue paper used to test materials for acid. It turns red in an acid.

loam (lōm), rich soil in which much humus is mixed with clay and sand.

lu cite (lü′sīt), the name of a very hard, clear plastic.

ma chine (mə shēn′), anything used to make work easier.

melt ing point (melt′ing point), the temperature at which a solid changes to a liquid.

min er al (min′ər əl), an element or compound that living things need. Minerals are taken from the soil by plants and used to make food.

mold (mōld), 1. a kind of fungus. 2. a hollow form into which a liquid may be poured to harden into a certain shape.

mov a ble pul ley (müv′ə bəl pu̇l′i), a pulley that moves with the weight; not a fixed pulley.

nec tar (nek′tər), a sweet liquid found in many flowers.

ny lon (nī′lon), the name of a material made from coal, water, and air. Nylon is often made into thread or cloth and used instead of silk.

pas teur ize (pas′tər īz), heat hot enough and long enough to kill certain germs.

pen i cil lin (pen′ə sil′ən), a powerful germ-killing drug made from a certain mold plant.

phys i cal change (fiz′i kəl chānj), a change in a material that does not make a new material.

plas tic (plas′tik), a material that can be easily shaped or molded.

pol len (pol′ən), fine yellowish dust on part of a flower. It helps to make seeds.

pro tec tive foods (prə tek′tiv füdz), foods that contain vitamins which help prevent diseases and keep us healthy.

pro te in (prō′tē in or prō′tēn), a compound of carbon, oxygen, hydrogen, and nitrogen. Sometimes it also has sulphur and phosphorus. Proteins are found in foods such as meat, fish, eggs, milk, etc.

prune (prün), cut off or cut out parts from. Trees are pruned by cutting out some of the smaller branches.

pul ley (pu̇l′i), a simple machine made of a wheel with a rope running over it. The wheel is usually grooved.

pul ley block (pu̇l′i blok), several pulleys used together in a frame.

queen bee (kwēn bē), the mother bee in a hive.

ray on (rā′on), the name of a material made from wood or cotton fibres. Rayon is often made into thread or cloth.

reg is ter (rej′is tər), an opening through which warm air or cold air can get into or out of a room.

rick ets (rik′its), a disease that causes soft and poorly formed bones. It is caused by lack of vitamin D.

roll er bear ing (rōl′ər bãr′ing), a bearing in which parts turn on a number of loose metal rollers.

root hairs (rüt hãrz), tiny hairlike roots through which water and dissolved minerals come into a plant.

ro te none (rō′tə nōn), a poison used to kill both chewing insects and sucking insects.

scur vy (skėr′vi), a disease caused by lack of vitamin C.

sim ple ma chine (sim′pəl mə shēn′), a machine that has very few parts. Levers, inclined planes, pulleys, and wheels and axles are all simple machines.

so cial (sō′shəl), living in a group.

stom ach poi son (stum′ək poi′zən), a poison that kills insects when they eat it with their food.

suck er (suk′ər), a small shoot of a plant that grows from the stem or root.

suck ing in sect (suk′ing in′sekt), an insect that gets food by sucking sap from leaves and stems.

thin (thin), make less thick or not so close together. A thick row of plants is thinned by pulling out some plants to give the others more room.

tile (tīl), a tube made of baked clay and used as a pipe.

tin der (tin′dər), a material that catches fire easily.

trans plant (trans plant′), plant again in another place.

vein (vān), a part of a leaf which holds tubes that carry water.

ven ti late (ven′ti lāt), change the air in. Windows are opened to ventilate a room.

vi ta min (vī′tə min), any of certain necessary materials found in foods. Lack of vitamins causes diseases and poor health.

wa ter jack et (wô′tər or wot′ər jak′it), a water-filled space around the firebox of a furnace.

wheel and ax le (hwēl ənd ak′səl), a simple machine made of a wheel fastened to an axle so that they turn together.

whey (hwā), the watery part of milk that separates from the thick part, or curd, when milk sours or cheese is made.

work er bee (wėr′kər bē), one of the bees that do all the work in a hive.

INDEX

In the next few pages is a list of things that your book tells about. This list is called an *index*. You can use the index to help you find things in your book.

Notice that all the words beginning with *A* come first. All words that begin with *B* come next. Find the words that begin with *S*.

Suppose that you want to find out about different kinds of bees. First, look for *bees* in the index. What pages in your book tell about bees? Look at page 13 and find out what it tells you about bees. What does page 21 tell you? Does page 14 tell you about the different kinds of bees in a hive?

Do ferns grow in the sunshine or the shade? How does the sun help all green plants? Find the pages in your book that tell you.

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